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PRINTED ON THIN PAPER FOR FOREIGN CIRCULATION.

ENGINEERING:

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An Illustrated Weekly Journal.

EDITED BY CHAS. COOPER AND J. FOSTER PETREE.

TEMPORARY OFFICES FOR ADVERTISEMENTS AND PUBLICATION, 18 & 20, COMPTON ROAD, HAYES, MIDDLESEX.

VOL. 151—No. 3927. LONDON: FRIDAY, APRIL 18, 1941 Registered at the General Post Office as a Newspaper PRICE 1s. BY FOREIGN POST 1s. 8d.

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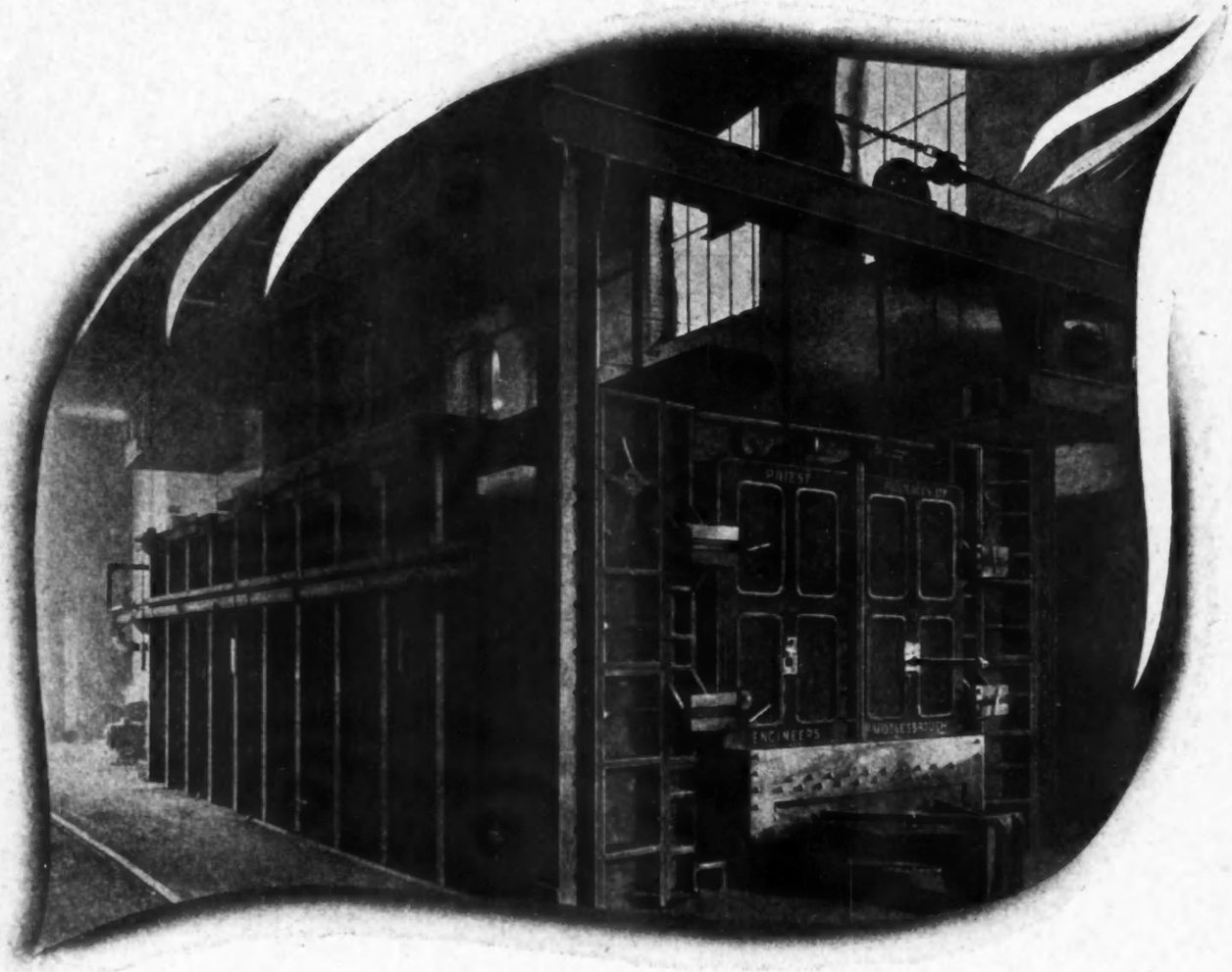

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THE BONNEVILLE DAM ON THE COLUMBIA RIVER, OREGON, U.S.A.

In accordance with the provisions of the River and Harbor Act, of the United States Congress, of January 21, 1927, a series of surveys was made by the Corps of Engineers of the United States Army for the purpose of formulating general plans for the improvement of the more important navigable rivers of the country. The objects kept in view covered not only increased navigational facilities, but the most effective utilisation of water power, the control of floods and the development of irrigation. Among these surveys, that dealing with the Columbia River was completed in 1932. This river, which rises in British Columbia and runs into the Pacific Ocean at a point some 80 miles west of Portland, Oregon, has a length of 1,210 miles. The total fall between the international boundary and the beginning of the tidal section, 143 miles from the mouth, is 1,284 ft. The plans put forward covered the construction of ten dams on the part of the river lying within the United States, located so that all but 95 ft. of the available head below the international boundary would be utilised. One of the dams, that at Rock Island, was already in existence, having been constructed by Messrs. Stone and Webster some years ago, for the Puget Sound Power and Light Company. Of the remaining nine, it was decided that dams at Bonneville and Grand Coulee should be proceeded with. That at Bonneville, which is described below, was undertaken first.

Before proceeding to a description of the Bonneville Dam, it will be of interest to give some account of the general configuration of the Columbia River. It has been stated that, from the point of view of power development, the river is "second to none in the United States." Of its total length of 1,210 miles, 465 lie in Canada and 745 in the United States. It drains an area of 259,000 sq. miles, 39,000 sq. miles of which are in Canada. The river rises in Columbia Lake, in British Columbia, which is situated at elevation 2,650. This lake is about 100 miles south-west of Calgary, in Alberta. For a distance of 195 miles the river flows in a north-west direction in the narrow valley between the foothills of the Rocky Mountains and the Selkirk Range, the heavily-timbered foothills rising to elevations of from 5,000 ft. to 6,000 ft., and the Selkirk Mountains being from 8,000 ft. to 10,000 ft. high. In this distance of 195 miles, the river has a fall of 650 ft. Just north of the 52nd parallel, it turns round the northern end of the Selkirk Range and flows almost due south in the valley between Monashee and the Selkirk Mountains. At the point where it changes direction, which is known as Boat Encampment, the Columbia is joined by the Canoe River from the north, and the Portage River from the east. It was up this latter river that early voyagers travelled from the Pacific to Hudson Bay.

From Boat Encampment to the United States boundary is about 270 miles, in which the river has a fall of 700 ft. It is confined within a narrow valley formed by a complex and irregular mountain system rising to elevations of from 4,000 ft. to 11,000 ft. Dense forests cover the lower slopes of these ranges, and there are numerous glaciers and extensive snow-fields at higher elevations, the river being reinforced by many glacier-fed streams. At places, the valley widens and in one of these two long narrow lakes are situated. The most northerly of these, Upper Arrow Lake, is 36 miles long, almost uniformly two miles wide and very deep. It has an arm on its east side, 10 miles long and a mile wide. Eighteen miles below, the Columbia flows into Lower Arrow Lake, which is 51 miles long. The southern part of this lake is shown in the map of the United States' part of the Columbia River, which is given in Fig. 2, on page 302. Below this lake, at a point 30 miles upstream from the boundary, the Columbia is joined by the Kootenay River, and by the Clark Fork River just north of the border.

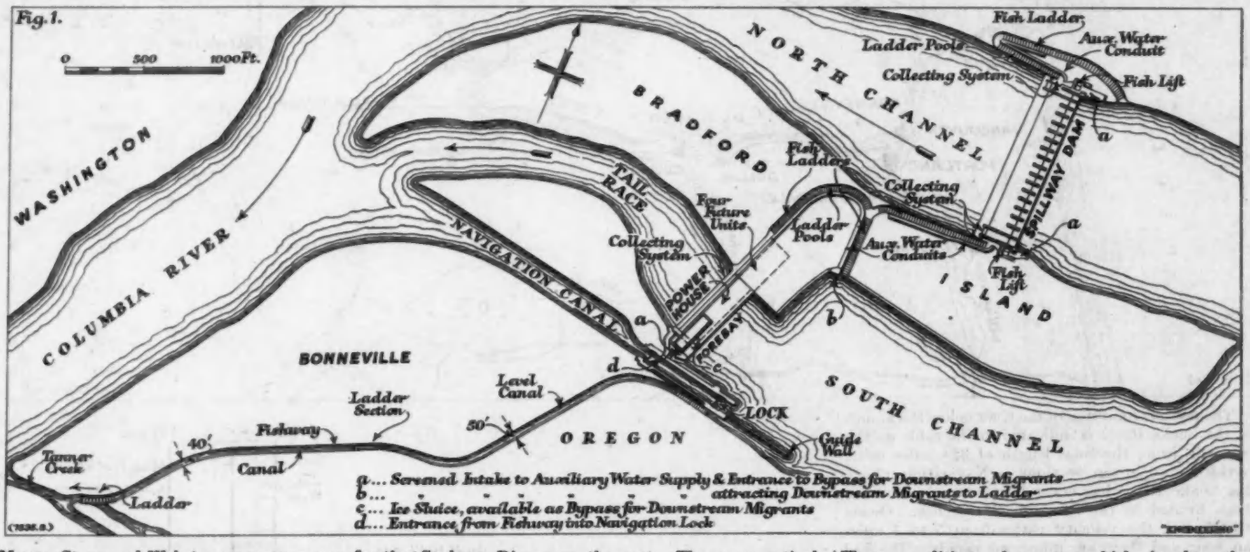
Below the Canadian boundary, the Columbia River continues to flow in a southerly direction for 112 miles, receiving in this stretch the waters of the Kettle River on the west and the Colville and Spokane Rivers on the east. The comparatively small Kettle and Colville Rivers are not shown in Fig. 2. The Columbia then turns abruptly west and flows in that direction for a distance of 108 miles to the eastern foothills of the Cascade Mountains. It then flows south again, for a distance of 205 miles, to its confluence with the Snake River. Between the Spokane and Snake Rivers, the Columbia is joined, from the north and west, by a number of swift tributary streams which rise in the Cascade Range. From the south and east, however, it is not joined by any stream of importance, the run-off from an area of over 9,000 sq. miles to the east of this section of the river being very slight. This area comprises a great treeless plateau, which has a rainfall varying between 6 in. and 14 in. per annum.

The Kootenay River, which makes an important contribution to the waters of the Columbia, rises in British Columbia at latitude 51 deg. N., on the west side of the Selkirk Range, and in the loop formed by the northerly and southerly flowing sections of the Columbia River. Its source is 80 miles north of Columbia Lake. It flows almost due south, and passes this lake, from which it is divided only by a mountain meadow. Turning south-east, the Kootenay crosses the international boundary into Montana at longitude 115 deg. After continuing to hold a southern course for about 45 miles, it turns north-west, passing through a corner of the State of Idaho and again crossing the international boundary. Some 23 miles from this point, it enters Kootenay Lake, as shown in Fig. 2. The section of the river lying inside the United States is about 167 miles long. Kootenay Lake is 66 miles long and varies in width from 2 to 3 miles. It is of great depth. About mid-point on the west side there is a narrow arm, through which the river leaves the lake and joins the Columbia River at a point 30 miles north of the border.

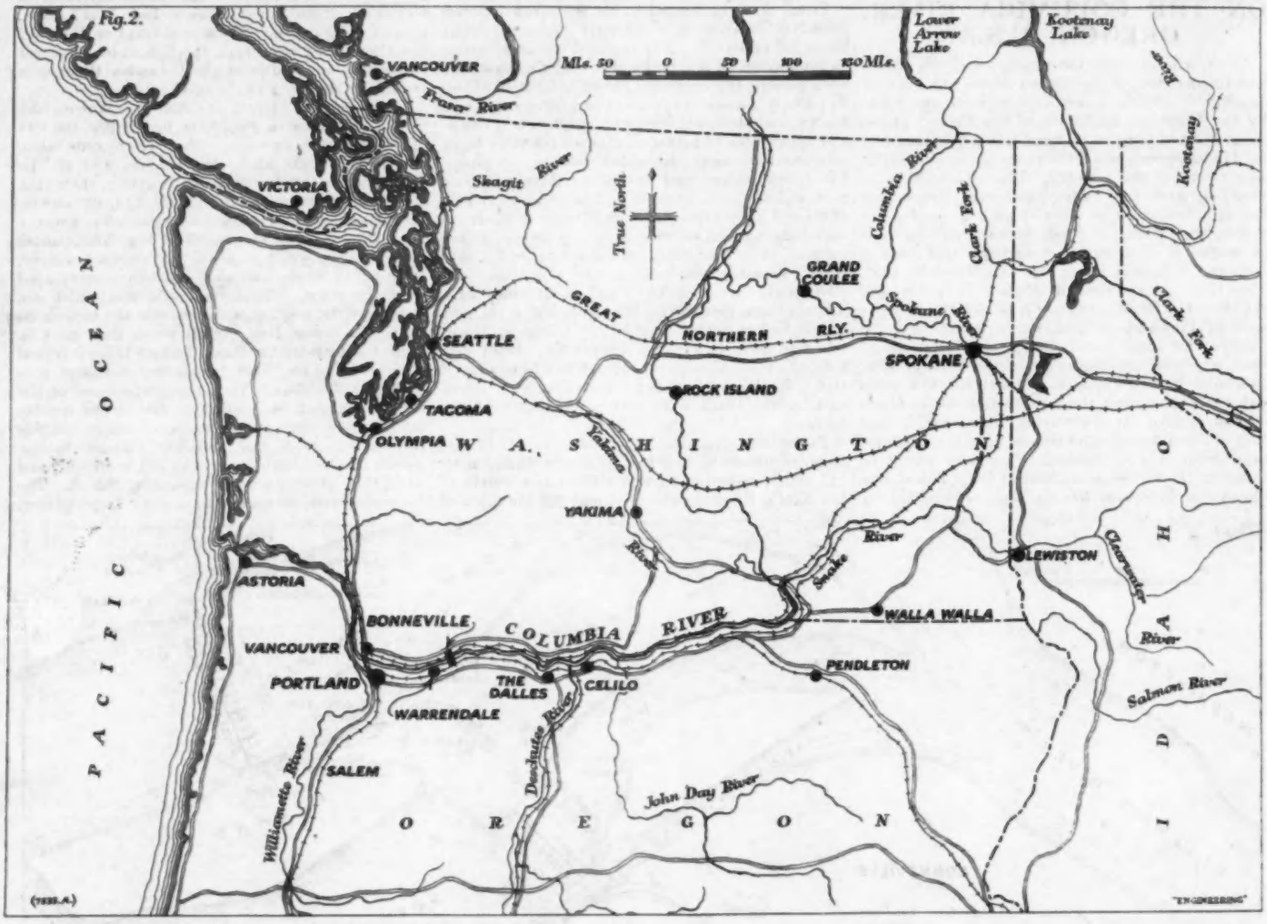
The Columbia River is tidal to Warrendale, which, as shown in Fig. 2, is just below the site of the dam at Bonneville. Discharge records taken at Cascade Locks above Warrendale, and at The Dalles, some 50 miles higher up the river, show that the mean flow at Bonneville is 214,000 cusecs, the minimum flow 40,000 cusecs, and the average flood flow 500,000 cusecs. The low flows, under 60,000 cusecs, which generally last only a few days, occur in the winter and are frequently accompanied by floating ice. The flood discharges, which are caused by the melting of the snow in the mountains above the headwaters, usually reach their peak in June. The maximum flood of which there is record occurred in June, 1894, when the discharge rose to 1,170,000 cusecs. The great importance of the river for power production is due to its rapidly falling profile and the existence of many suitable dam sites. From the Canadian border to the mouth of the Snake River, the fall is 975 ft., and from this latter point to tidewater, 309 ft. The low-water flow is usable to a very large extent. These conditions, however, which involve the existence of many rapids, make the river, in general, unsuitable for navigation above tidewater. From the point of view of irrigation, the possibilities are promising. There is a large area of semi-arid country, with fertile soil, within the river basin and situated so as to be within economic reach of irrigation schemes.

Considering the Columbia River from the standpoint of navigation, it may be divided into three sections. These are the tidal reach extending upstream 143 miles from the mouth; the middle section from the head of tidewater to the mouth of the Snake River, a distance of about 180 miles; and the upper reaches, from the Snake River to the boundary, covering about 424 miles. The early agricultural and commercial development of the river basin was largely due to the navigation facilities provided by the main stream and its tributaries. These facilities, particularly those provided by the tidal reach, remain to-day an important factor in the economic welfare of large parts of the States of Oregon and Washington. Since the signing of the treaty between Great Britain and the United States, which settled the "Oregon Country" controversy, the Corps of Engineers of the United States Army has conducted many studies of the Columbia over the length between the International boundary and the Pacific Ocean and has improved the channel over various sections. The treaty, which was signed in 1846, gives British subjects the right to navigate the Columbia River to its mouth.

Fig. 1.

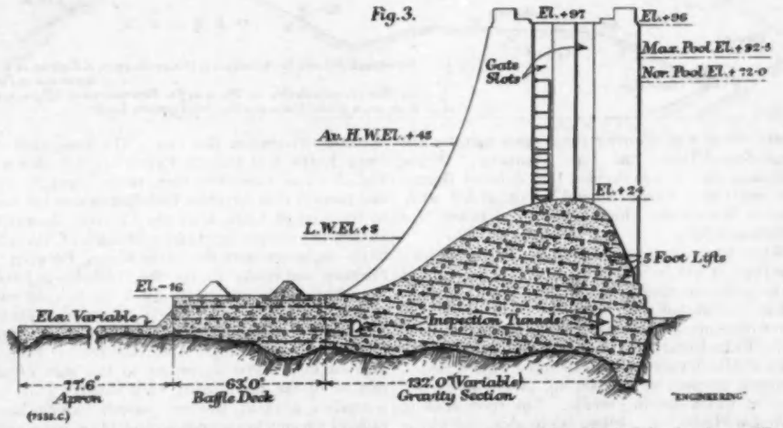


THE BONNEVILLE DAM ON THE COLUMBIA RIVER, OREGON, U.S.A.



The present condition of the river below the mouth of the Snake River is indicated in the table on the opposite page, the total length of 324 miles being divided into seven sections. Navigation above the Snake River has never been extensive, having been limited to the less difficult reaches. Owing to the fall, the velocity varies from 5 to 7 miles an hour and there are numerous rapids. The bed is, however, very stable, being composed of material not easily transported even by the rapidly flowing river. At the present time, only launches operate on this section.

As mentioned above, after the completion, in 1932, of the survey of the Columbia by the Corps of Engineers of the United States Army, it was decided to proceed with dams at Bonneville and Grand Coulee. The position of both these dams is indicated in Fig. 2. Both of them are now completed, but Bonneville was first put in hand, its construction being authorised on September 30, 1933. It was built by the Corps of Engineers. At the site of the dam, 42 miles east of Portland, the river flows in a westerly direction in two channels, which are separated by Bradford Island, as shown in the map reproduced in Fig. 1, on page 301. The main channel, north of the island, which forms the boundary between the States of Washington and Oregon, has an average width of 600 ft. The northern shore, between the upper and lower limits of the dam site, consists of sand, gravel, clay and boulders, with no certain bedrock in evidence at any point. The eastern end of Bradford Island lies at only a small elevation above the river. When work was started, it was covered with brushwood, but in the photograph reproduced in Fig. 6, on Plate XXIV, this has been practically cleared and some material dumped from the dam works, which are shown in course of construction. About midpoint of the island, the ground rises in an upstream



direction to a summit elevation of 195 ft. and then drops steeply to river level. A boulder reef extends upstream for about 1,250 ft., and connects with Boat Rock, which is a small solid basaltic island situated about midstream. It lies outside the range of Fig. 1. Boat Rock shows columnar structure along several hundred feet of its vertical northern side and a laminated lava formation on its less steep northern side.

The higher upstream part of Bradford Island consists, in the main, of a conglomerate formed of pebbles and rock fragments firmly consolidated in volcanic ash; this is locally known as Eagle Creek formation. The island terminates at its upstream end in nearly vertical cliffs. The Oregon shore, from opposite Boat Rock to a point about one-third of the length of Bradford Island, shows Eagle Creek formation with masses of dislodged Columbia basalt which have slid down from the cliffs. This is followed for a short distance by a solid jointed basalt which penetrates and is integral with the Eagle Creek conglomerate. The remainder of the Oregon shore, down to the mouth of Tanner Creek, is a flat composed of sand, gravel and boulders. Bonneville Station, on the Union Pacific Railroad, and a State fish hatchery, are located at Tanners Creek.

As will be seen from Fig. 1, a spillway dam has been constructed across the north, or main, channel and a power-house dam and navigation lock in the south channel, which is known as Bradford Slough. A view of the spillway dam during construction is

given in Fig. 4, on Plate XXIV, and a view of the power-house dam in Fig. 5. This latter shows the downstream side of the station. The dams are connected by an earth bank across the island. The spillway dam is a gravity structure carrying a series of reinforced-concrete piers 10 ft. thick, the space between the piers being 50 ft. wide. In these spaces vertical lift gates are located. A section of the dam, which shows the profile of the piers, is given in Fig. 3, opposite. The total length of the dam proper is 1,090 ft., there being 18 gates. These are all 50 ft. wide; three at each end are 60 ft. high, the remainder being 50 ft. high. The total length of spillway crest is, therefore, 900 ft. The gates are of riveted-steel construction and are each divided horizontally into two sections arranged with latching mechanism so that either the upper half or the whole gate may be lifted. They are operated by one or other of two gantry cranes which travel on the upper roadway connecting the piers. One of these cranes can be seen at the right-hand side of Fig. 4, Plate XXIV. The lifting mechanism control allows the gates, which weigh approximately 200 tons, to be moved by a single operator.

NAVIGATIONAL FACILITIES ON THE COLUMBIA RIVER.

Section.	Length in Miles.	Fall in Feet.	Current.	Description.
1. Mouth of river	—	—	Tidal	Improved for seagoing vessels. Two jetties. Depth 40 ft.
2. Mouth to Vancouver	104·5	5·6	Tidal	Depth 30 ft. from Vancouver to Willamette River; 35 ft. below mouth of Willamette.
3. Vancouver to Warrendale	35·5	7·0	Moderate current	Tidal, unimproved; 8 ft. deep channel.
4. Warrendale to Head of Cascades	7·0	37·0	Rapids	Cascades by-passed by canal with locks. Open river improvement for 4½ miles to Bonneville.
5. Head of Cascades to The Dalles	41·0	4·0	Moderate current	Natural 8 ft. channel; no project for improvement.
6. The Dalles to Head of Celilo Falls	12·0	82·0	Rapids	By-passed by Celilo Canal with locks.
7. Head of Celilo Falls to Snake River	124·0	185·0	Swift, with rapids	Open river improvement.

The spillway dam was built inside rock-filled crib cofferdams, the construction and placing of which formed one of the most interesting features of the Bonneville dam project. This work will be described later in this article, but it will be convenient to give some details of the dam itself at this stage. The concrete was supplied from a mixing plant set up on the Washington side of Bradford Island and was distributed to the job by buckets running on a double cableway spanning the works. One of the towers of this cableway can be seen on the right of Fig. 8, on page 310, which shows the dam during the construction of the piers. The towers were mounted on tracks and had a side travel of 850 ft. The span of the cableway was 2,020 ft. The concrete plant embodied two mixers of the automatic batching type with a combined capacity of 3,000 cub. yd. per day of 24 hours. As far as was practicable, the concrete was delivered directly by cableway bucket to its place in the structure, but for the many positions which were inaccessible for the buckets, owing to the nature of the forms or the extensive reinforcement, concrete-pumping plants were provided.

Mass concrete in the gravity section of the dam was placed in 5-ft. layers, on a slope of 1 in 8, dipping upstream. The specification required that the pours should remain uncovered for 72 hours for cooling. To control the generation of heat still further, and so discourage the formation of cracks, it was specified that the concrete should contain 25 per cent. of calcined puzzolanic material. In the mass concrete, from 0·9 to 0·95 barrel of this material was used per cubic yard. The rise in temperature when the concrete was placed in 5-ft. layers was about 35 deg. F. The foundation was grouted from the bottom of a cut-off trench excavated on the upstream side. After grouting, the trench was filled with concrete. The grouting holes were drilled at 10-ft. centres in a longitudinal line, alternate holes, at 20-ft. centres, being grouted first. In excavating for the foundations, the rock was tested for seams by core drilling, in order to ensure that final excavation should be carried down to solid material.

From the cross section, given in Fig. 3, it will be seen that the width of the gravity dam, including the baffle deck, is 195 ft. The height from the lowest point of the foundations is 170 ft. The elevation of the gate sills, at the crest of the gravity dam, is at + 24 ft. and the normal pool elevation, at + 72, extends about 45 miles upstream to The Dalles. The minimum depth of the pool is greater than 30 ft. The reinforced-concrete cut-off wall, already mentioned, which has a minimum thickness of 4 ft., is carried into the bank at each abutment. At the Bradford Island end, the wall makes contact with an impervious formation, and at the Washington end, it is carried sufficiently far into the bank to provide a safe percolation path around the end of the dam. Reinforced-concrete counterfort-type wing walls extend 120 ft. upstream at each bank to protect the ends of the dam and provide a controlled stream flow to the gates.

The spillway is designed to pass a flood of 1,170,000 cusecs, equal to the maximum recorded on June 6, 1894, without raising the previously-attained flood elevation at Cascade Locks, six miles upstream. This condition is attained with Bradford Slough closed by the power-house dam, although at the time of the recorded maximum flood this channel was open to assist in the escape of the water. The spillway piers and the overhead roadway are actually high enough to pass a flood of 1,600,000 cusecs, which is 37 per cent. greater than the flood of 1894. As will be seen from the construction views reproduced in Fig. 7, on Plate XXIV, and Figs. 8 and 9, on page 310, the piers are heavily reinforced. The steelwork has been designed to withstand both direct pressure and the side pressure which is set up when some gates are opened and others are left closed. As shown in Figs. 8 and 9, part of the reinforcement is of structural steel; this supports the gate guides, which are concreted in.

Protection against the scouring effect of the water passing over the spillway is secured by the provision of reinforced-concrete baffles on the baffle deck, and by the wide concrete apron at the toe, as shown in Fig. 3. The baffles are of wedge shape, 6 ft. high, 2 ft. wide at the top and both the upstream and downstream faces are inclined at 45 deg. Their form is very clearly shown in Fig. 7. They are arranged in two rows, in staggered formation, across the full length of the dam. The baffle shape and arrangement were determined by model tests carried out in the Bonneville Hydraulic Laboratory of the Corps of Engineers. Maintenance of the baffles has been provided for by constructing a caisson which can be floated into place and sunk over any three blocks in one row. It seals on the deck and can be pumped out to permit inspection of, or repair to, the blocks. This work is carried out in the low-water season and flow opposite the caisson is reduced by closing the appropriate spillway gates.

Although Figs. 7 and 8 will be understood from the preceding description, it will be realised that no explanation has been given of the timber bulkhead shown closing one of the spillway bays in Fig. 9. This concerns the procedure adopted in the building of the dam, which will be dealt with in the next section of this article. In order to explain Fig. 9, it may be stated briefly that the dam was constructed in two parts by closing half the width of the river at a time by means of cofferdams. The northern half, of which Fig. 9 shows a part, was built first. In order to leave as free a passage as possible for the river while the cofferdam for the southern half was being constructed, the gate sills of the northern half were not at first constructed to the finished height. They were completed, when the other part of the dam had been finished, by closing the bays in turn by means of a portable caisson and a timber bulkhead, so that work could be carried out on the gate sills. Fig. 9 shows the fitting of this bulkhead.

(To be continued.)

LITERATURE.

The High-Speed Internal-Combustion Engine. By HARRY R. RICARDO, F.R.S.; revised by H. S. GLYDE. London and Glasgow: Blackie and Son, Limited. [Price 30*s.* net.]

THIS is the third edition of a book first published 18 years ago, the second edition of which was issued ten years ago. A new preface explains that, owing to present activities of the author, the task of revision has been undertaken by Mr. Glyde, an assistant of 17 years' standing at Mr. Ricardo's Shoreham Laboratory. The general outline of the work is already well known, and the principal feature calling for comment in the present issue is Mr. Glyde's rewritten chapter on "Diesel Engines." There are, however, certain other directions in which the revision might have been extended with advantage. Mr. Glyde's foreword expresses acknowledgments to seven individuals (in addition to the original author) for their aid in various ways; yet the only reference in the book to the late Sir Dugald Clerk quite incorrectly attributes to him the original development of supercharging, "thirty years ago." Readers of the last volume of ENGINEERING will recollect that this was actually introduced by the late Mr. J. H. Hamilton, of the Premier Gas Engine Company (now Crossley-Premier Engines, Limited) so long ago as 1890. Certainly, in 1903 or thereabout, Clerk did patent, in conjunction with the National Gas Engine Company, a method of topping-up charges with air or exhaust products, mainly as a means of controlling detonations in engines working with coke-oven gas; but this hardly warrants the attribution to him, in a book written by such an authority as Mr. Ricardo, of the first development of supercharging.

The long description of internal-combustion engines for tanks, given in Chapter IX, refers to those of 25 years ago. The equally lengthy treatise on liquid fuels of the vaporising class is based on work that was completed more than 20 years ago. Perhaps, when conditions permit, similarly complete trials may be made with modern Diesel fuels. It is evident that Mr. Ricardo is a protagonist for the increased use of industrial alcohol, from vegetable sources, to lessen the degree of reliance upon imported fuels. Much of the chapter on high-speed Diesel engines deals with what may be described as the Ricardo type of engine. The information given is interesting and valuable, including an epitome of the various conclusions drawn from the intensive research work undertaken over many years at the Shoreham Laboratory, as modified by the results of practical operation of many types of engines, commercialised on the basis of those researches.

It is understandable that Mr. Glyde should have hesitated to disturb more than he could avoid of the original matter of the book, which is an excellent example of the peculiarly attractive style of which Mr. Ricardo is an acknowledged master; but there is no doubt, unfortunately, that much has been retained that can hardly be regarded as useful to designers of the present day, and occasionally the failure to revise more thoroughly has led to inconsistencies between the old matter and the new. For instance, on page 31, it is stated that "to judge of the quality of a fuel by its specific gravity is entirely misleading; yet, on page 392, five Diesel fuels are referred to in terms of specific gravity as well as cetane enumeration, and, on page 408, tests are cited in which "the minimum consumption per brake horse-power-hour is 0·354 lb. of commercial Shell Diesel oil of specific gravity 0·875." It will be seen, therefore, that the book calls for a certain circumspection in reading; but, granted this requirement, most of its matter may still be read with profit.

THE ENGINEERING OUTLOOK.

IX.—Marine Engineering.

Activity in marine engineering and shipbuilding during 1940 has been limited only by the available supply of skilled labour and of raw materials. Although no statistics for the output of these industries are available, it has been stated in the House of Commons that the Admiralty estimate of merchant shipbuilding in the first year of war was 1,250,000 tons. The exact basis of this estimate is not known, but it may be compared with launchings of 1,018,000 gross tons in 1938 and 1,486,000 gross tons in 1930. It must not be overlooked, however, that naval shipbuilding was at a very low level in 1930, and that, in spite of the pre-war armament programme, it must have been very much higher in 1940 than in 1938. Statistics for the output of marine engines are no longer available, but figures of employment in marine engineering are shown in Table I, herewith. Between

Table I.—*Marine Engineering: Total Employment in the United Kingdom.*

Date.	Nos. Insured.	Nos. Unemployed.	Nos. Employed.
July, 1929 ..	58,450	5,211	53,239
,, 1930 ..	60,670	9,347	50,723
,, 1931 ..	55,240	26,224	29,016
,, 1932 ..	50,530	29,274	21,256
,, 1933 ..	46,220	21,833	24,387
,, 1934 ..	46,750	13,621	33,139
,, 1935 ..	45,650	12,049	33,601
,, 1936 ..	49,960	6,013	43,947
,, 1937 ..	53,780	4,391	49,389
,, 1938 ..	57,180	4,247	52,933
,, 1939 ..	59,940	3,963	55,977
,, 1940 ..	—	989	—

July, 1939, and July, 1940, unemployment in the industry fell from 3,963 to 989. There was also probably a substantial rise in the numbers insured.

Table II, also on this page, shows United Kingdom exports of marine engines to the end of 1939. It has not been possible to separate the figures into exports during the first eight months of the year and those for the first four months of the war. In view of the requirements of the home market, however, it is virtually certain that exports have been very small since the start of the war. The smooth development of the merchant shipbuilding programme was considerably upset by the course of the war during the early part of 1940, and particularly by the collapse of France, since this necessitated a substantial increase in the construction of naval vessels.

Another factor which is frequently overlooked in assessing the capacity of British yards for new construction is the very high rate of repair work necessary in war time. Apart from repairs due to the normal hazards of the sea, and those ships which are damaged by enemy action but which succeed in reaching their home ports, considerable numbers of wrecked ships are salvaged. These must either be reconditioned or broken up for the recovery of scrap. In July, 1940, when the Merchant Shipping (Salvage) Bill was passed, it was stated that the Admiralty had taken over almost the whole of the salvage organisation in the country, and that, since the beginning of the war, upwards of 100 vessels, totalling nearly 500,000 tons, had been successfully salvaged. Speaking on the Navy Estimates in March, 1941, Mr. A. V. Alexander stated that, by the end of 1940, the number of salvage vessels was nearly double what it had been a year earlier, and that the total tonnage rescued and saved up to December 31, 1940, was over 1,000,000.

It appears that, during the first year of war, British shipyards were able to replace about 77 per cent. of the losses of British shipping due to enemy action, which amounted to 1,611,842 gross tons. Losses of allied and neutral ships, however, totalled about two-thirds of the British figure; and, since all the principal neutral shipbuilding yards, with the exception of those of the United States, are now under enemy control, the output of the British shipyards should be compared with the total losses of 2,855,870 gross tons. Towards the end of 1940, shipping losses became more serious, and the total of British, allied and neutral losses for 1940 was about 3,600,000 tons. Presumably, there was also some increase in the new output from British yards, since Mr. Arthur Greenwood stated in December that, since May, 1940, output had increased by 50 per cent.

Down to the end of 1940, the deficiency between losses of British tonnage and new construction was practically made up by transfers from other flags and captured vessels, and in January, 1941, Sir Arthur Salter stated that we still had more than 97 per cent. of the total sea-going tonnage that was under the British flag in 1939. Since the outbreak of war, we had chartered four million tons of neutral and allied shipping, and had purchased over 500,000 tons, mainly from the United States. Captures and the chartering of neutral vessels, however, cannot be expected to yield any appreciable tonnage during the current year, so that future losses, which may well be on a heavier scale than in 1940, must be made good from the shipbuilding resources of this country and the Empire, and from increased purchases in the United States or transfers under the Lease and Lend Act.

It is clear from these figures that the need for drastic reductions in imports of certain commodities has not arisen entirely from actual losses of ships. More important factors up to the present have been the increase in the average length of voyages, due to the fact that imports previously obtained from Scandinavia and the Low Countries must now be brought from farther afield; the loss of time in the formation of convoys; the lack of escort vessels, which means that separate convoys cannot always be formed for fast and slow ships; the need for importing greatly increased supplies of war materials of all sorts; and, perhaps most important of all, the high proportion of the total available shipping required to supply the Army in Africa and the Near East. The solution of the problem is, therefore, being sought along two main lines: to secure the most intensive use of the existing shipping, for example, by cutting down the time required for loading and unloading, and to increase shipbuilding capacity in this country, throughout the Empire and in the United States. The first of these courses does not primarily concern the shipbuilding and engineering industries, and in the attainment of the latter, so far as this country is concerned, the most important consideration is probably an expansion of the supply of skilled labour.

During July, concern was expressed at the alleged unemployment of skilled shipyard workers in certain parts of the country. It was also pointed out that, owing to the contraction of the shipbuilding industry since the last war and more particularly since 1930, a number of skilled workmen had left the industry and accepted other employment. On behalf of the Government it was stated that a review of the labour supply was taking place with representatives of employers and employed. It was expected that the results of this review would show which men were suitable for immediate employment in the shipyards, as well as those who could be absorbed if given the chance to become fit again for such work. In the meantime, an appeal was made to all skilled shipyard workers then in less essential employment to inform their local employment exchanges that they would be ready to go back to their old trade if they were still suitable. It is understood that this appeal met with a good response. Glasgow Corporation, for example, who were large employers of shipyard labour in their various departments, agreed to release about 600 skilled men.

In the following month, a scheme was instituted for the emergency transfer of labour, intended to apply particularly to repair work. Each shipbuilding area was to have a joint committee representing the employers, the unions and the Government. Arrangements were made for payment by the Government of the outward fare of men transferred, and by the employer for the return fare as well as allowances for travelling time and a lodging allowance for nights spent away from home. At the same time, labour supply officers were appointed for the shipyard areas, with duties corresponding to those of the labour supply officers in the munitions industries.

Nevertheless, as the output increased, the question of skilled labour continued to give difficulty, particularly since there was little prospect of employing women in the shipbuilding industry. In March, 1941, the Essential Work (Shipbuilding and Ship Repairing) Order, 1941, was issued by the Minister of Labour, under which the First Lord of the Admiralty became responsible for the most efficient use of labour within the industry. The Minister of Labour, however, continued to be responsible for the supply of labour from outside the industry. A small committee, representative of the industry and consisting of two employers and two workers under an Admiralty chairman, was set up to meet from time to time as occasion demanded. In the shipbuilding areas, local controls were set up under the flag officer in charge of the port. Under him the local control consists of three executives representing, respectively, naval shipbuilding and repair, merchant shipbuilding and repair, and labour. The local control is concerned with local priorities and is also responsible for the day to day allocation and interchange of labour in the district, and for the transfer of labour from one district to another. Explaining the new method of control, Mr. Ernest Bevin made a further appeal to men who had drifted into other occupations to return to shipbuilding. He stated that the problems of the shipbuilding industry could be solved by the new Order if an additional 50,000 workmen could be provided in the right categories.

As stated in this series last year, the fact that the shipbuilding industry was able to start the war with a substantial tonnage under construction was due in large measure to the loans and grants promised under the British Shipping (Assistance) Bill, 1939, which was allowed to lapse on the outbreak of war. In the belief that the Bill would become law, orders were placed for about 100 vessels. The loans were not, in fact, withdrawn, but the first instalment of the grants, which were to have totalled 2,500,000*l.* spread over five years, were not forthcoming on April 1, 1941, and this occasioned some anxiety to shipowners who had placed orders. It was announced, however, in a White Paper issued early in August, that the initial grants would be made, amounting to a sum estimated at about 320,000*l.* The White Paper also set out the financial details of the requisitioning agreements between the Government and British shipowners. As all new merchant shipbuilding is now on Government account, the level of freight rates does not have the same influence on current shipbuilding orders as in

Table II.—United Kingdom Exports of Marine Engines and Machinery. (000*l.*)

	1930.	1931.	1932.	1933.	1934.	1935.	1936.	1937.	1938.	1939.
Fitted in Ships:										
1. *Steam*—										
Reciprocating engines ..	1,311	520	245	101	160	221	336	465	751	333
Turbines	683	831	176	81	—	67	92	37	2	7
Boilers	837	503	201	84	83	104	229	199	374	199
Other machinery	633	591	232	186	61	155	196	163	212	293
2. *Motor Ships*—										
Engines	2,899	813	65	44	85	197	308	153	560	645
Other machinery	464	163	49	8	63	64	86	37	184	89
Separate:										
Steam reciprocating	169	74	28	25	31	27	23	41	151	73
Internal combustion	477	237	223	364	395	378	403	501	617	476
Steam turbines*	—	—	—	—	—	—	—	—*	225	312
Total	7,473	3,722	1,319	895	877	1,233	1,673	1,596	3,076	1,427

* Not separately recorded prior to 1938.

peace time. Nevertheless, the agreed rates are of considerable importance, as they have been attacked on the grounds that they do not allow the shipowners to make adequate provision for depreciation; a fact which, if true, must have serious effects on both the shipping and shipbuilding industries after the war. Many shipowners appear to be anxious that the Government may intend to nationalise the shipping industry after the war, and they complain particularly that they are not allowed to spend on new ships the money paid to them in compensation for war losses. They claim that, under the present procedure, the Government are both paying compensation and buying the new ships, and thus are paying out approximately twice as much as is necessary. At the same time, there is considerable criticism of the types of ship now being built, on the ground that these will not be suitable to meet foreign competition after the war.

In order to secure the greatest possible rate of output, a large measure of standardisation and simplification of design is inevitable, and this, coupled with the fact that current shipbuilding costs are extremely high, would seem to imply that, even from the shipowners' point of view, there are certain advantages in Government purchases of the current output of the shipyards. It cannot be denied, however, that the accumulation of a large number of ships in Government ownership, for the most part unsuitable for peace-time requirements, and the gradual depletion of the privately-owned fleets, will present a formidable problem at the end of the war. An outline of the Government plans for assistance to the shipping industry after the war was expected, but no such outline was included in the White Paper issued in August.

Although, as stated above, there has been a considerable rise in shipbuilding costs since the outbreak of war, a system of control of prices has been in force since that time and the increases that have taken place have been closely related to the rise in the cost of materials and of labour. The present system appears to have been accepted as fair both by the builders and the purchasers, and it has been suggested that a similar method of control might with advantage be instituted in normal times. Apart from the labour question and the maximum degree of standardisation and simplification of design, steps have been taken to increase output by re-opening a number of yards for the construction of "fabricated" ships. This method was adopted during the last war as an expedient to replace heavy losses. The shipyard becomes virtually an assembly centre, standardised sections being produced at the steelworks, or, if necessary, imported, for rapid assembly.

Attention has also been devoted to the expansion of shipbuilding capacity throughout the Empire, particularly in Canada and Australia. In May, 1940, it was announced that the Canadian shipbuilding programme was well ahead of schedule. The current two-year programme involved the construction of over 100 vessels for Naval and Air Force purposes, including 64 patrol ships and 26 minesweepers. It was stated that some of these ships would be delivered in 1940 and the remainder in 1941. In January, 1941, the Canadian Department of Munitions and Supply announced that contracts had been placed for 20 anti-submarine craft, while later in the month, contracts were placed by the British Government for 18 merchant vessels, each of 9,300 tons deadweight. The contracts were divided equally between the shipbuilding companies at Quebec, Montreal and Vancouver. In November, 1940, it was reported that the Dominion Government were considering the establishment of a shipbuilding industry capable of constructing large warships. Early in 1940, the 18 principal Canadian shipyards were employing about 17,000 men, and the total value of orders placed since the outbreak of war amounted to 15,500,000*l*.

In the case of Australia, it was stated in September, 1940, that seven shipyards were building 50 patrol craft to the Navy Board's design. At the beginning of 1941, the Broken Hill Proprietary Company stated that their activities were to be extended to shipbuilding; and, in March, a Commission was appointed by the Australian Government to organise merchant shipbuilding in that country. It is expected that the Commission will concentrate on the building of standard ships of 4,000 to 6,000 tons, principally for the coastal trade, to replace vessels diverted overseas. Later, ships may be built up to 10,000 tons.

It is clear, however, that the main increment to the shipbuilding capacity of this country must be sought in the United States. At the end of 1940 it was stated that the United States proposed to make a start with 60 ships for this country, which would be completed in about 12 months. Subsequently, the number was increased to 400, and there is little doubt that, in due course, the rate of building will be substantially increased. Comparisons have recently been made with the United States shipbuilding effort of the last war, when, in certain cases, ships were completed in the exceptionally short period of 29 days. The total launchings in 1918 amounted to about three million gross tons. In the long view, it is anticipated that the recent agreement between the United States and Canada regarding the St. Lawrence Waterway will facilitate the use of the Great Lakes shipyards for the construction of vessels for this country. In March, 1941, it was announced that Sir Arthur Salter, Parliamentary Secretary to the Ministry of Shipping, would go to America to discuss arrangements for the maximum assistance in shipping.

DISCOVERY AND INVENTION.*

By SIR RICHARD GREGORY, Bart., F.R.S.

(*Continued from page* 296.)

RADIO-COMMUNICATION and broadcasting are impressive examples of practical developments directly derived from original scientific investigation undertaken with no other purpose than that of inquiring into natural causes, consequences, and relationships. Reasoning on principles discovered by Faraday as to the nature and influence of the electromagnetic field, Clerk MAXWELL, in 1864, succeeded in proving by mathematical equations that light is an electromagnetic effect, and that waves originating in wires conducting electric currents are propagated through space with the same velocity—186,000 miles a second. The only difference between waves which affect the sense of sight and those used in broadcasting is in wavelength, or pitch, to use a musical comparison. Before MAXWELL had arrived at his results it had been suggested that such periodic oscillations were produced whenever electric discharges took place under certain conditions; but it was his convincing mathematical reasoning arising out of experiment that led to their practical confirmation. In 1883, Professor G. F. FITZGERALD indicated how waves of a calculable wavelength must arise from the oscillatory discharge of an electric condenser. Five years later, Sir Oliver LODGE succeeded in confirming mathematical theory and prediction by generating electric waves in wires and measuring their wavelengths, the shortest of which, in his experiments, was found to have a length of 9 ft. In the same year, 1888, HERTZ discovered how to produce and detect such waves in free space and thus gave physical reality to purely mathematical conceptions. The first demonstration that the waves could be used for signalling, and would pass through walls of buildings, was made by Sir Oliver LODGE in 1894. The "invention" stage of the subject began two years later, when MARCONI, who had been experimenting with electric waves in Italy, came to England and took out the first patent ever granted for radio-telegraphy.

The development of radio-communication, from telegraphic signalling by the Morse code to the transmission of speech and other sounds by the telephone, was based upon the discovery that the glowing carbon filament of an electric lamp gave rise to discharges of negative electricity. This is known as the "Edison effect"; and its nature was investigated by fixing within a glow-lamp a thin platinum plate to collect the negative discharge and convey it outside the bulb by an insulated wire. Twenty years after this "thermionic" phenomenon had been discovered, Sir Ambrose FLEMING made a detailed study of it and communicated the results to the Royal Society. He surrounded the filament with a thin metal cylinder supported within the glow-lamp by a platinum wire. By this device the rapid alternating current produced at an electric power station could be "rectified" so that it became of the one-way character necessary for use in telephony. FLEMING patented his electric valve in 1904 as a means of rectifying and detecting wireless waves, and thus bridged the gap between laboratory experiment and practical invention. Three years later, Dr. Lee de FOREST modified the FLEMING valve by interposing copper gauze, or a spiral of thin wire, between the incandescent filament of a glow-lamp and the platinum plate. By the introduction of this "grid," the flow of electrons from the filament can be controlled and magnified at either a transmitting or receiving station, and several of these three-electrode, or triode, valves can be joined up in series to increase the effect desired.

There was an interval of 24 years (1864-1888) between the publication of MAXWELL's theory of electromagnetic waves and their actual generation by LODGE and HERTZ: eight years elapsed (1888-1896) before the first wireless patent was taken out by MARCONI; 21 years (1883-1904) between the discovery of the Edison effect and FLEMING's patent; only two years (1904-06) separated this valve from de FOREST's triode with its grid, which led to the beginning of broadcasting in the United States 14 years (1906-1920) later, and the establishment of the British Broadcasting Company in 1922. It took more than half a century, therefore, for this great engineering performance to fulfil the promise revealed by MAXWELL in his mathematical conclusion concerning the propagation of electromagnetic waves in space.

The bright filaments of the thermionic valves used in broadcasting, and also in most electric glow-lamps, are now nearly always made of the metal tungsten, which can be raised to a higher temperature than any other metal without melting and gives off a copious supply of electrons when incandescent. Tungsten was isolated in a metallic state from its compounds so long ago as 1783, and it remained a curiosity of the laboratory until the middle of the Nineteenth Century, when its use in the production of special steel alloys began to assume industrial importance.

At the beginning of the present century, the use of tungsten in steel manufacture became general; and a few years later filaments of the pressed metal were used in glow-lamps, but they were too fragile for reasonable length of service to be widely adopted. The production of ductile tungsten was both a discovery of a particular nature of the metal and an invention of high scientific and industrial importance. After a long and intensive series of experiments in the research laboratories of the General Electric Company, Schenectady, U.S.A., Dr. W. D. COOLIDGE found that, by welding together powdered tungsten into the form of rods and heating this compressed material, it could be consolidated and hammered while hot, so that finally it could be drawn out into extremely fine and strong wires with a high degree of ductility. To draw any distinction between discovery and invention in the history of these developments, or between researches carried out in academic and industrial laboratories would be to make an invidious separation of motives. All that need be said is that the metal and the means of making it ductile were available for more than a century before original thought and experiment used them for the production of an invention which has proved of very great scientific and commercial value.

The uses of the special properties of tungsten for inventive purposes is only one example of many in which important industrial applications have grown out of the discovery of new metallic elements, often after a long interval. One of the best known of these metals is manganese. The metal was first obtained in a pure state as a laboratory product towards the end of the Eighteenth Century; but in this form it has no industrial value. Several millions of tons of manganese ores are, however, now mined annually, and 95 per cent. of it is used in the production of alloys of iron and steel and other metals. The use of manganese in modern steel-making began in the first quarter of the Nineteenth Century, when a patent for it was taken out by J. H. HEATH. This discovery, or invention, led to developments which have revolutionised the art of steel manufacture. Systematic research on the influence of different proportions of manganese upon the properties of alloy steels were begun by Sir Robert HADFIELD in 1882; and they resulted in the discovery of his famous manganese steel, containing about 13 per cent. of manganese. He took out the first patent for this discovery in the following year. It marked the dawn of the age of high alloy steels; and to-day nearly the whole of the world's output of steel makes use of manganese in one form or another.

Other chemical elements first isolated in the course of scientific research, and now used in the production of alloy steels with special properties are nickel, chromium, tungsten, molybdenum, cobalt, silicon, vanadium and aluminium. Stainless steels contain either about 12 per cent. of chromium alone, or with about 7 per cent. of nickel. High-speed tool steels contain about 16 per cent. of tungsten, other alloying elements in much smaller percentages being manganese, silicon, chromium and vanadium. Tungsten steel is also largely used in the construction of permanent magnets for magnetos

* Aldred Lecture delivered before the Royal Society of Arts, Adelphi, London, W.C.2, on Wednesday, March 26, 1941. Abridged.

and other apparatus subject to powerful demagnetising influences. Cobalt steel is superior for this purpose, but more costly to produce. The chemical element, silicon, was obtained in the form of an amorphous powder early in the Nineteenth Century, but its importance in steel manufacture was not discovered until about seventy years later, when Sir Robert Hadfield invented the iron-silicon alloy known as silicon steel. No other steel alloys possess the special properties of manganese and silicon steels or can replace them efficiently in engineering practice; manganese steel on account of its durability and toughness, and silicon steel by greatly reducing losses in electrical transformers and other machines.

The principles of expansion, compression and evaporation of fluids used in refrigerating machines were established by laboratory experiments on the nature of heat before they were applied to industry. The action of a refrigerating machine is the reverse of that of a heat engine, but the laws of thermodynamics determine the performance of both. By a series of experiments carried out by Joule and Thomson (Lord Kelvin) in the 'fifties of the Nineteenth Century, it was shown that, when gas under high pressure was allowed to escape through a small orifice or porous plug, the result was a lowering of temperature of the gas. Air under pressure thus allowed to escape undergoes a reduction of temperature of about $\frac{1}{4}$ deg. C. for a pressure difference of one atmosphere. This is known as the Joule-Thomson effect, and is the basis of many commercial processes for cooling and liquefying gases.

For nearly half a century before the Joule-Thomson effect was used in the construction of refrigerating machines and the liquefaction of gases, a method of cooling by mechanical means had been invented. The earliest type of refrigerating machine, which produced cold by causing compressed and cooled air to expand by working a piston in a cylinder, was patented in the United States in 1850. It was not, however, until twenty years later that the mechanical production of cold began to have a commercial value. In 1879, the S.S. Strathleven was fitted with a cold-air machine of this type, and a cargo of frozen meat was successfully brought from Australia to England. At the end of the century, about two million carcases of beef and mutton were brought to England annually in ships fitted with these refrigerating machines. Compressed-air machines then began to be replaced by machines using other gases, such as carbon dioxide and ammonia, and it became possible to preserve many other food products from deterioration during transport or over a long period.

Towards the end of the Nineteenth Century, the Joule-Thomson effect was given industrial importance by the invention of refrigerating machines based upon it. The cooling effect produced by the escape of a compressed gas from a nozzle or valve is used to cool the inflowing gas, and thus introduce a regenerative process, which can be continued until the gas is liquefied. Most modern refrigerating machines depend upon this principle, and the regenerative process is used to produce the very low temperatures required for the liquefaction of atmospheric air and its components, oxygen and nitrogen. The separation of oxygen and nitrogen from air is carried out by allowing liquid air to drop slowly into liquid oxygen. The neon gas present in air, and familiar in the neon tubes used for illuminated advertisements and other purposes, is a by-product of this process.

(To be continued.)

THE VACUSTAT.

It is perhaps scarcely necessary in considering the new form of vacuum gauge illustrated in Figs. 1 and 2, accompanying, and known as the Vacustat, to enumerate the many purposes for which a high vacuum is required in modern times, but the wireless valve, the photo-electric cell, the vacuum flask, and some types of electric lamps may be cited as examples of comparatively recent date in the widening field of application. Taking it for granted, then, that the high vacuum is a present-day need, and ignoring the question of its production, modern methods of measuring vacua are obviously of importance. Of the several methods available, we are here concerned only with those which depend for their operation on Boyle's law relating the pressure and volume of a gas, since the Vacustat belongs to this class.

With a high vacuum, the tenuity of the gas is such that no readily-handled instrument can measure it directly, but on decreasing this tenuity by compressing a definite portion of the gas, measurements become practicable. The Vacustat is a modification of the gauge invented by Professor McLeod, of Coopers Hill College, as far back as 1874, and still extensively used both for high-vacuum measurement and for calibrating other low-pressure devices. The McLeod gauge, in its simplest form, consists of a glass bulb prolonged at the top into a sealed capillary tube

"VACUSTAT" GAUGE FOR HIGH VACUA.

MESSRS. W. EDWARDS AND COMPANY (LONDON) LIMITED, LONDON.

Fig. 1.

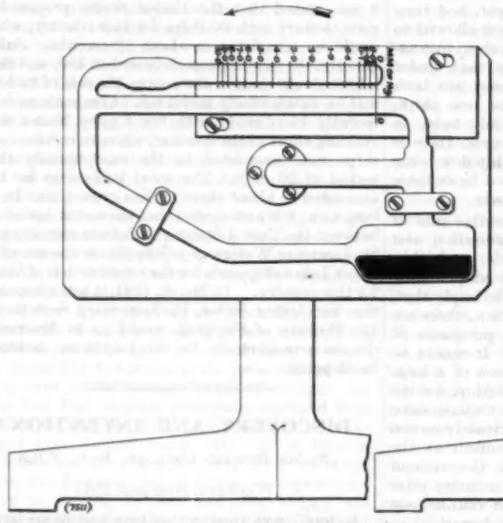
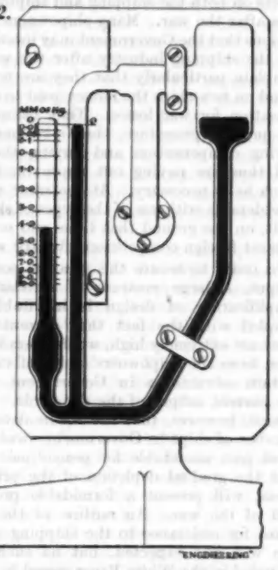


Fig. 2.



and at the bottom into a tube which is connected by rubber tubing to a reservoir containing mercury and capable of being raised and lowered. Just below the bulb a branch is led upwards for some distance and is coupled at the top, by means of rubber tubing, to the apparatus containing the gas of which it is required to measure the residual pressure. This branch, however, is bifurcated in the region of the bulb in a manner that may best be visualised as a by-pass, which is formed as a capillary running parallel to the bulb capillary and sharing with it the measuring scale. The upper part of the by-pass, of course, joins the branch again. When the gauge is not in use, the lower tube of the bulb is sealed by the mercury in the reservoir, which is then in its lowest position, while the bulb is in free communication with the vacuum apparatus. But, when the reservoir is lifted the mercury rises in the lower tube and closes the opening of the branch just below the bulb. Further lifting of the reservoir results in the charge of gas in the bulb being compressed and ultimately driven into the bulb capillary by the rising mercury. This mercury ascends in the by-pass capillary also, and to a greater height since the pressure in this capillary is only that existing in the vacuum apparatus, while in the bulb capillary the pressure is higher owing to the volume of gas originally in the bulb being compressed into the much smaller volume of the capillary. Since the volume of both the bulb and the bulb capillary are known and the difference in level between the mercury in the bulb capillary and the by-pass capillary can be measured, it is possible to determine the pressure in the apparatus which is connected to the vacuum gauge by a simple calculation involving the use of Boyle's law.

A number of modifications and improvements of the original McLeod gauge have been made by different workers and firms but, with a few exceptions, such as Reiff's tilting gauge, they have all had the drawback of needing an overall height in excess of the barometric column and of requiring rather tedious manipulation. The Vacustat has been developed by Messrs. W. Edwards and Company (London), Limited, Allendale Works, Southwell-road, London, S.E.5, in order to eliminate this general inconvenience. Its height is only 9 in. and this compactness, coupled with the fact that it is self-contained and requires only approximately 8 cub. cm. of mercury, makes it readily portable. The capillaries, scale and bulbs are all attached to a rectangular plate, which is pivoted on a tripod stand in such a way that it can be rotated in the vertical plane through an angle of 90 deg. The glass assembly has an outlet connection, through the centre of the pivot, terminating in a stainless-steel nipple, a rubber tube connecting the nipple and the apparatus to be exhausted. The rubber tube is sufficiently flexible to permit the rotation of the plate.

The Vacustat is shown in Fig. 1, in the position required when the apparatus is being exhausted and it will be clear that the whole system is at the same degree of vacuum as the apparatus. To make a reading of the vacuum or, rather, of the residual pressure of the gas, the plate is turned into the vertical position, as shown in Fig. 2. This movement cuts off the bulb, and fills it and part of its capillary with mercury, thus compressing the gas in the remaining part of the bulb capillary. The mercury in the by-pass capillary, of course, rises higher, since it is still in communication with the exhausted apparatus. As shown in the figure, the mercury level in the by-pass capillary is at the zero mark at the top of the scale and bulb capillary, and when this is the case the pressure of the gas in the apparatus being exhausted is shown directly by the level of the mercury in the bulb capillary read on the pressure scale in millimetres of mercury. It will be noticed that the pressure scale is not uniformly divided, this being due to the fact that the pressure being measured is approximately proportional to the square of the difference in level between the mercury in the bulb capillary and by-pass capillary. If V is the combined volume of the bulb and the bulb capillary, v is the volume per unit length of the latter, and h is the difference in level of the mercury, the pressure, $p = \frac{v h^2}{V}$ for practical purposes, consistent units being used throughout. Since the ratio $\frac{v}{V}$ is a constant for any particular gauge, the scale can be graduated as shown to read the residual pressure directly. It should be noted that the level in the by-pass capillary remains virtually at the zero for any pressure within the range of the gauge since the capacity of the mercury reservoir bulb is large compared with the capacity of this capillary. If a correction is desired, the gauge may be tilted very slightly to run the mercury in the by-pass capillary up to the zero mark, but, seeing that the instrument is intended for production work and not for precise laboratory experiments, such a correction is generally unnecessary. The capillary diameter is considerably exaggerated in Figs. 1 and 2 for the sake of clearness. The scale, it will be observed, is mounted with slots for the holding screws, to provide means for zero adjustment, and is graduated with a range of from 10 mm. to 0·01 mm. of mercury. It may be mentioned that although Messrs. Edwards have developed this convenient gauge in order to meet a demand for a compact and easily-manipulated instrument, they also manufacture the conventional McLeod patterns as well as other types of vacuum gauge, the choice of a gauge being determined by the particular requirements to be met.

The World Production of Tin.—According to statistics issued by the Tin Research Institute, the world production of tin during February was 17,800 tons, compared with an output of 17,400 tons in January. The production for the first two months of the present year was thus 35,200 tons, against 30,800 tons in January and February, 1940. The consumption of tin in the United Kingdom, in January, was 2,672 tons, against 2,198 tons in December and 2,620 tons in January, 1940

JIG-BORING MACHINE.

MESSRS. NEWALL ENGINEERING COMPANY, LIMITED, PETERBOROUGH.

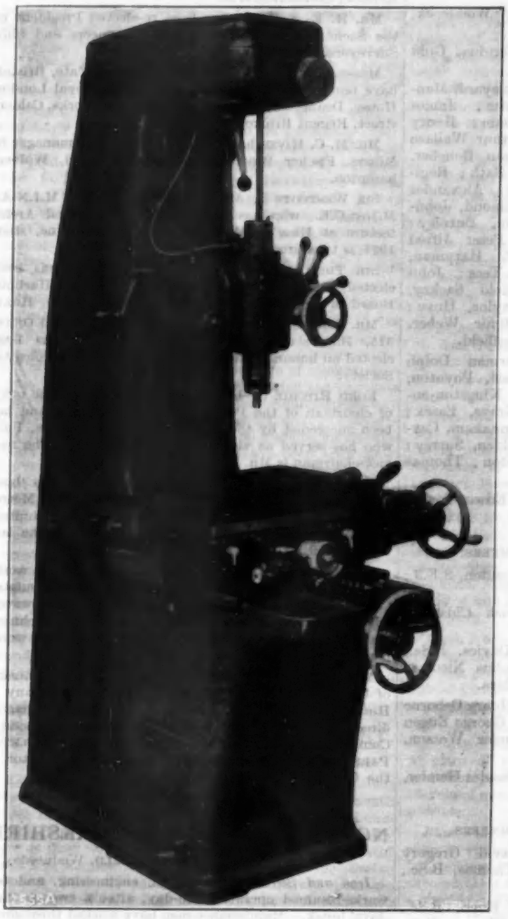


FIG. 1.

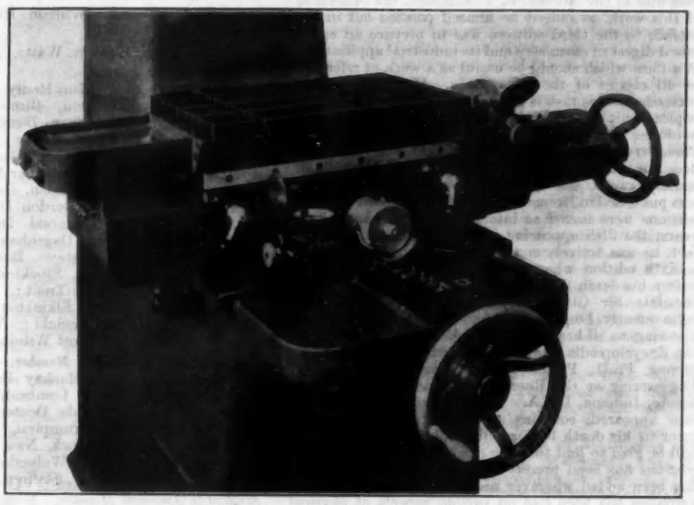


FIG. 2.

JIG-BORING MACHINE.

THE open-sided jig-boring machine, with the roller system of linear measurement for setting the table for drilling holes in precise positions without preliminary marking-off, was introduced by Messrs. Newall Engineering Company, Limited, Peterborough, in 1936, and an illustrated account of it in its early form was given in ENGINEERING, vol. 142, page 682 (1936). This machine has proved so useful that a demand has arisen for a smaller one embodying the same principles, and this demand has been met by the development of the machine shown in Figs. 1 and 2. Known as the Newall Jig-Borer Model O, it is marketed, as also is the larger size, by Messrs. E. H. Jones (Machine Tools), Limited, Edgware-road, The Hyde, London, N.W.9. It is intended for precision work of moderate dimensions, and has a table with a working surface measuring 18 in. by 12 in. The longitudinal traverse is 12 in., and the transverse traverse is 9 in. The quill head has a vertical adjustment of 6 in., and the quill itself a traverse of 5 in., these dimensions giving a maximum distance from the spindle nose to the table surface of 14 in., and a minimum distance of 3 in. The distance from the centre line of the spindle to the face of the column is 11¼ in.

The spindle drive is by a ¼-h.p. motor, the speed range being variable in infinitely small steps between 113 r.p.m. and 1,800 r.p.m. This useful speed variation is obtained by the employment of a Ward-Leonard control set housed in a separate steel cabinet, which can be arranged near the machine in any position convenient to the operator. The control gear is fully enclosed and the external fittings comprise a speed-adjusting rheostat knob and dial, start and stop push-buttons, and main isolating switch. Flexible bushings are used in the mounting of the unit within the cabinet to damp out vibration. A three-speed gearbox in the machine, controlled by a lever on the column, is used in conjunction with the Ward-Leonard unit for the speed variation. The spindle feed may be either by power or by hand. Three rates of power feed are provided, namely, 0·0015 in., 0·003 in., and 0·006 in. per spindle revolution. Each rate is available for any spindle speed. Coarse hand-feed is obtained by means of the starwheel seen to the right of the spindle head in Fig. 1, and fine hand-feed by the hand-wheel in front of the head.

The measuring arrangements for setting the table are best seen in Fig. 2. As stated, the roller system developed by Messrs. Newall is employed, and, though there are some minor differences between the arrangement shown and that first adopted, the original principle remains unchanged. It consists in the provision of a row of rollers, each 1 in. in diameter, all in contact with one another and arranged in channels on the two centre lines of the table traverse. These channels can be readily distinguished in the figure by the serrated appearance of their sides, the serrations, however, being merely part of the roller-retaining device and not themselves playing any part in the actual measuring operation. The cylindrical objects seen above both the longitudinal and transverse traverse roller channels are micrometer devices termed micro-locators. They are detachable and rest on the top of the rollers, the underside being fitted with a Vee-shaped ridge at one end, which enters the groove formed by the opposing quadrants of any pair of rollers. A hardened, ground and lapped ball point at the opposite end of the underside of the micro-locator provides the other necessary support. The micro-locator has a central horizontal plunger, which is actuated by a micrometer screw. The whole arrangement has the same function as that of a row of standard measuring blocks, in that it enables the table to be set in either direction with a guaranteed precision of 0·0002 in. in the desired measurement of the drill-hole centres. The micro-locator is moved along the rollers to give whole inch measurements, its adjustment by the micrometer screw providing the fractional inch measurements. The setting manipulation, of course, is much simpler than that needed when gauge blocks are used; for one thing, there is not a string of dimensions to be added up, the setting of the micro-locator by means of its graduated thimble making it the exact length required to give a dimension composed either of whole inches plus fractions, or a fractional dimension only. A linear scale alongside each roller channel facilitates the setting of the micro-locator for the 1-in. measurements.

Referring again to Fig. 2, it will be seen that a dial indicator is mounted on both the table and the table saddle. The plunger of this indicator bears on one end of a centrally-pivoted lever, the other end of which, provided with a ball point, bears on the plunger of the micro-locator. The dial indicator plays no part in the actual measurement, as, to set the work in either direction at a given distance from, say, the first hole centre, it is only necessary to adjust the micro-locator for position and length to the required dimension and bring the table into contact with the micro-locator plunger. This would, however, introduce a personal element, as the machine operator could not be relied upon to secure an invariable degree of pressure in the contact. The introduction of the lever-operated dial indicator eliminates this source of error. The indicator is graduated in divisions of 0·0001 in., as also is the thimble of the micro-locator. The rollers are of hardened, ground and lapped steel and are finished with a chromium deposit prior to lapping. They are 1 in. in diameter, within limits of ± 0·0002 in. Tests have shown that the rollers retain their dimensions to a highly satisfactory degree. A set of ten rollers measured in March, 1937, were again measured in August, 1938. The average maximum variation in diameter in this period was only 0·00002 in. Similar tests in 1939 and 1940 confirmed these results. There was no variation in circularity between the first and second tests. The overall dimension of the ten rollers, placed in side contact, was 10·00024 in. in March, 1937, and in August, 1938, was 10·00023 in. The table-locking device, lubricating arrangements, finish and other constructional details not specifically mentioned are, in general, similar to those of the larger machine.

TRAFFIC ON THE PANAMA CANAL.—Official figures published recently show that 5,058 ocean-going vessels, carrying 26,546,579 tons of cargo, passed through the Panama Canal during the calendar year 1940, as compared with 5,928 ships and 29,081,360 tons in 1939. The value of the tolls paid declined from 23,707,000 dols. in 1939 to 19,952,000 dols. in 1940.

LIGHTING OF PUBLIC-SERVICE VEHICLE GARAGES.—The Ministry of Home Security announces that a circular relative to concessions in the present lighting restrictions in connection with public-service vehicle garages has recently been addressed to Chief Controllers. The circular indicates that, in view of the importance of maintaining as efficient a transport system as possible under present conditions, it is considered that exemptions may properly be granted in respect of lighting visible at doorways of public-service vehicle garages or other essential openings, provided that the roof and any side windows are completely blacked out; that the doorways and other openings are screened so far as practicable without interfering unduly with the movement of vehicles and that the "spill" of light at such an opening does not exceed an intensity of 0·002 foot-candle on the ground. Lighting of this character may be permitted to be retained after a "purple" message or "red" warning and up to the alarm given by a spotter, where such retention is necessary to ensure the due operation of a passenger transport service.

NOTES ON NEW BOOKS.

Kingzett's Chemical Encyclopædia. Revised and edited by Professor R. K. Strong. Sixth edition. London: Baillière, Tindall and Cox. [Price 45*s.* net.]

The aim of the late Mr. C. T. Kingzett, the originator of this work, as indeed he himself pointed out in the preface to the third edition, was to prepare an epitomised digest of chemistry and its industrial applications in a form which should be useful as a work of reference to all classes of the community. How well he has succeeded in his task is evidenced by the well-thumbed copies of his encyclopædia which are to be encountered in offices, works and libraries up and down the country. Chemistry, however, in common with other sciences, does not stand still, a fact of which Mr. Kingzett was acutely aware, and following the first edition, which was published in December, 1919, four successive revised editions were issued at intervals of from two to four years, the fifth appearing in May, 1932. In point of fact, he was actively engaged in gathering material for a sixth edition when he became ill, and some time before his death the work of revision was entrusted to the late Sir Gilbert Morgan, O.B.E., F.R.S., who subsequently, however, was himself forced to relinquish it owing to ill-health. The task of editor-in-chief of the Encyclopædia was then assumed by Professor R. K. Strong, Ph.D., Professor of Chemistry and Chemical Engineering at the Rose Polytechnic Institute, Terre Haute, Indiana, U.S.A. The sixth edition, which has now appeared, contains a foreword contributed just prior to his death by Sir Gilbert Morgan. Old readers will be glad to find that the original plan of the earlier editions has been preserved. New material, however, has been added wherever needed and some additional emphasis has been laid on various aspects of physical chemistry. Much new matter has been inserted relating to such subjects as *p*H values, industrial solvents, the science and practice of chemical engineering, the production and importation by various countries of chemical commodities, and the high- and low-temperature carbonisation of coal. In addition, the entries dealing with abrasives, Diesel oil, dyes, electrons, fats, glass, paper, petroleum, rubber, soap, sulphur, and other matters, have been revised and considerably expanded. While all these developments have increased the bulk of the volume, they have also, of course, considerably enhanced its value as a work of reference. Although Professor Strong has been careful to leave the general arrangement of the work unaltered, there are evidences of American influence; a good many of the more recent references are to treatises and technical journals published in the United States; under the entry "Strength," the tensile strengths of metals and alloys are given in pounds, instead of tons, per square inch, and such spel ings as "liter" are sometimes employed.

General Engineering Handbook. Editor-in-Chief, Professor C. E. O'Rourke. London: McGraw-Hill Publishing Company, Limited. [Price 28*s.*]

This is the second edition of a work published seven years ago, and it covers a wide range of engineering subjects: although some omissions can be noted, it is remarkable that so much has been included. On the civil engineering side, the absence of references to docks and harbours may be accounted for by the natural attitude of editors in a continental country, who are faced with the necessity of cutting out some material, but the omission of information on waterways and irrigation is more surprising. In the mechanical and electrical branches of engineering, the sections, previously published, on water and electrical power plants, power transmission, and welding, have been cut out, in order to bring the volume within reasonable dimensions. The mathematical section is so condensed, especially in the more advanced work, that it might have done little harm to condense it still farther into a mere statement of formulæ, which, in fact, would have been all that is necessary. Some of the mathematical tables, on the other hand, are taken to nine significant figures, which is quite unnecessary accuracy for ordinary engineering purposes. Taking the volume as a whole, however, the material is excellent and very well arranged; a great deal of valuable information has been collected in its 1,180 pages and, owing to the use of a high-grade India paper, the type and diagrams are clear and yet the volume is of a size suitable for handling. A word of commendation should be added in regard to the indexing, which is so important in a work of reference such as this; a sectional index on the flyleaf, outline synopses at the beginning of each section, and a full index at the end of the book add greatly to its value as a work of reference. Altogether, this is a very handy volume, at a reasonable price.

The American Oil Industry.—The output of crude oil in the United States, during the week ending March 15, averaged 3,662,450 barrels daily, as compared with 3,633,450 barrels in the previous week.

INSTITUTION ELECTIONS.

Institution of Structural Engineers.

Member.—Einer Boeck-Hansen, Ewell, Surrey; William Hughes, Surbiton, Surrey.

Associate to Member.—William Henry Woodcock, London.

Associate.—John William Watts, Koforidua, Gold Coast Colony.

Associate Member.—William Henry Appleyard, Manchester; Thomas Atkinson, Birmingham; James Baptie, Glasgow; John Barr, Birmingham; Henry Edwin Bartley, Addlestone, Surrey; Arthur Wallace Berriff, London; Cyril Thomas Goodman Boucher, Rowton Bridge, Chester; Gadadhar De, Bath; Reginald Bryan Dorman, Chaddesden, Derby; Alexander Douglas, Stafford; David Gordon Drummond, Johnstone, Renfrewshire; Desmond Durkin, Burnley; George Bernard Godfrey, Dagenham; Peter Alfred Greenway, Reading; Gustavo Donaldo Harpman, Cheltenham; John Potter, Stockton-on-Tees; John William Rutter, Stoke-on-Trent; Arnold Sackey, London; Donald Joseph Elkington Taylor, Hove; Norman Thomas, Huddersfield; Vladimir Weber, London; David Robert Scott Wilson, Sheffield.

Graduate to Associate Member.—Norman Dolph Beech, London; James Mackay Bennett, Poynton, Cheshire; Basil Glover Combridge, Kingston-on-Thames; William Richards Dexter, Grays, Essex; Thambiah Guneratnam, Urumpirai, Chunnakam, Ceylon; Dennis Frank Johncock, New Malden, Surrey; Douglas Leatherland, B.Sc., Wolverhampton; Thomas Benjamin Walmsley Newby, Stafford.

Student to Associate Member.—Norman Edwin Tovey, Coventry.

Institution of Chemical Engineers.

Member.—Moritz Hirsch, Dipl. Ing., London, S.E.3; Samuel Slater Lloyd, Croydon.

Associate Member to Member.—Patrick Chisholm Young, M.A., D.Phil., Croydon.

Associate Member.—Drury Norman Davies, B.Sc., A.I.C., Feltham, Middx.; Daniel Jacobus Nicolaas Hoffman, M.Sc., M.S., Pretoria, South Africa.

Graduate to Associate Member.—Alfred Henry Osborne Johnson, B.Sc., A.I.C., London, S.E.18; George Eugen Sachs, B.Sc., Leeds; Thomas Alexander Watson, B.Sc., A.R.C.Sc., London, W.C.2.

Student to Associate Member.—Victor Charles Hender, B.Sc., London, W.C.2.

Institution of Electrical Engineers.

Associate Member to Member.—David Gregory Brown, B.Sc., Yeovil; Thomas Rees Thomas, B.Sc., Cardiff.

Associate Member.—Arthur William Boyd, B.Sc., Slough, Bucks; Edmond Valentine Cleary, B.E., Dublin; Oluwaji Oladotun Coker, B.Sc., Jos, N. Nigeria; Robert Bigland Dickinson, London, S.W.3; Captain Leslie William Dunkley, R. Signals, Peterborough; Maurice Edmond J. Gheury de Bray, Weymouth; Lewis William Hipwell, Huddersfield; William Knowles, Droylsden, Manchester; Ronald David Lunnon, London, N.22; Major Geoffrey David Pegler, M.Sc., R.A.O.C., Newcastle-upon-Tyne; Edward William H. Powell, Cardiff.

Associate to Associate Member.—William Hall, New Barnet, Herts; Ernest Alfred Hounsell, London, W.C.2; Robert Speirs, Stanmore, Middx.

Graduate to Associate Member.—Alexander Frederick G. Allan, London, N.W.9; Reginald Wingate C. Byrne, London, N.10; James Conning, Prescot, Lancs; William Cover, East Barnet, Herts; William Stephen Crew, Romford; Henry Davies, Bedford; Clarence Richard Dudley, Ditherington, Shrewsbury; John Cornelius Fitzmaurice, Leatherhead, Surrey; Geoffrey Floyd, London, S.E.10; Harold Darrel Furber, Bahrain Isles, Persian Gulf; John Richard Gauntlett, Witbank, Transvaal, S. Africa; Thomas Gordon Hammerton, B.Sc., Ph.D., Coventry; Harry Bleamire Hewitson, Slough, Bucks; Albert Lee Jeffs, B.Sc. (Eng.), Cheltenham; Major Michael Ward Kendall, R.A.O.C., London, S.W.1; Ian Ferguson Lochhead, B.Sc., Oldham; Alexander McDonald, London, W.C.2; Percy Hayward Pettifor, B.Sc. (Eng.), London, S.E.3; Donald Allsopp Picken, Dowlais, Glam.; Frederick Harry A. Richards, Stretford, Manchester; Harold Robertson, Pinner, Middx.; Robert Scott, B.Sc., Larkhall, Lanarkshire; Edward William Shepherd, Portsmouth; John Watson Smith, Dunedin, N.Z.; Jesse Bertram Supper, Frimley, Aldershot; Reginald Charles Tuffnell, London, E.2; Edward William Weaver, Southampton; John Leonard Wooldridge, B.Sc. (Eng.), Edinburgh.

Student to Associate Member.—Hugh Craig Stevenson, B.Sc., Edinburgh.

PERSONAL.

Lieut.-Commander N. Fane, R.N.R., who is at present on active service, has been elected a director of Messrs. Broadway Engineering Company, Limited, Carlisle-road, Hendon, London, N.W.9.

Mr. H. E. J. Camps has been re-elected President of the Society of Consulting Marine Engineers and Ship Surveyors.

Messrs. Newman Industries, Limited, Yate, Bristol, have removed their Midlands office from Royal London House, Deansgate, Manchester, to Ordsall Works, Calder-street, Regent Bridge, Salford, 5.

Mr. M. C. Hives has been appointed sales manager to Messrs. Fischer Bearings Company, Limited, Wolverhampton.

Sir Westcott S. Abell, K.B.E., M.Eng., M.I.N.A., M.Inst.C.E., who has been Professor of Naval Architecture at King's College, Newcastle-upon-Tyne, since 1928, is to retire in September.

Sir Thomas A. L. Brocklebank, Bart., has been elected chairman of the Mersey Docks and Harbour Board in succession to the late Sir Richard D. Holt.

Mr. John Patterson, Director, Meteorological Office, 315, Bloor-street West, Toronto, Canada, has been elected an honorary member of the Royal Meteorological Society.

Lord Ritchie of Dundee has retired from the office of chairman of the Port of London Authority and has been succeeded by the Rt. Hon. Thomas Wiles, P.C., who has served as vice-chairman since 1934. The new vice-chairman is Mr. L. H. Bolton.

Mr. I. R. Cox, D.S.O., A.M.Inst.C.E., has been appointed joint managing director of Messrs. Metropolitan-Vickers Electrical Export Company, Limited, 1, Kingsway, London, W.C.2, in succession to the late Mr. C. S. Richards.

Mr. E. A. Bayles retired from the position of works manager at the Helsby Works of Messrs. British Insulated Cables, Limited, on March 31. His services, however, will be retained in a consultative capacity in technical matters. Mr. G. H. Walton has been appointed works manager at Helsby as from April 1.

Mr. Kenneth Edward Greig, lately general manager of The Taikoo Dockyard and Engineering Company of Hong Kong, Limited, has been appointed managing director of Messrs. Scott's Shipbuilding and Engineering Company, Limited, Greenock. Mr. Douglas Middleton Farnham Phillips has been appointed a director of the Company.

NOTES FROM SOUTH YORKSHIRE.

Sheffield, Wednesday.

Iron and Steel.—All the steel, engineering, and tool works resumed operations to-day, after a two or three days' break. Maintenance men have worked throughout the holiday overhauling furnaces and machines that have been operating at full capacity since the beginning of the year. As more works extensions are coming into use, production is rising in many industries. Increased outputs are reported in the raw and semi-finished steel-making trades. Bookings for steel strip tend to grow, while bars and rods are selling well. Users of structural steel report that supplies are sufficient to meet their requirements. Larger tonnages of pig-iron and East Coast hematites are coming forward to this area, but forward buying is out of the question. Scrap dealers are handling record tonnages, and consumers have no difficulty in obtaining supplies. The heavy machinery and engineering trades continue to be busily employed. Valuable contracts for a large variety of machinery have been placed on home account, and, judging by the growing number of inquiries in circulation, other orders are pending. Firms specialising in the production of railway rolling stock are accounting for increased outputs. Rolling mills and forges are operating at full capacity, and re-rollers are busy. In the medium branches, the position shows little change. The seasonal trade in agricultural machinery and parts is at a high level, and large tonnages of agricultural steel are leaving this area to firms in various parts of the country specialising in the construction of all types of farm machinery and implements. Another progressive line is pump manufacture, the Colonies being good customers. Makers of petrol and steam engines are satisfactorily employed. There is a steady demand for electric motors, and progress is reported in the production of concrete and cement-mixing machines, mechanical trench diggers and excavators.

South Yorkshire Coal Trade.—Collieries in this area are accounting for larger outputs, and the consumption of all grades of industrial coal is particularly heavy. Locomotive coal is in better demand, and steams are being disposed of in larger quantities. Smalls and slacks are active media. The house-coal market is also brisk, and more coal is moving to the south of England. All types of cokes have maintained their position.

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Scottish Steel Trade.—Easter has had no effect on the Scottish steel trade from the point of view of production. The demand for plates from the shipyards is heavy and near date delivery cannot be promised except under first-class priority. In one or two branches of the industry arrears have been well overtaken and makers are able to give fairly prompt delivery. Makers of sheets have a large tonnage of work on hand, both black and galvanised varieties being in demand. Orders for structural sections are not so numerous at the moment and fairly reasonable delivery can be promised. Steel scrap is somewhat scarce and although fairly good stocks are held, an increase in the supply would be welcome. The following are the current quotations:—Boiler plates, 17*l.* 12*s.* 6*d.* per ton; ship plates, 16*l.* 3*s.* 0*d.* per ton; sections, 15*l.* 8*s.* 0*d.* per ton; medium plates, ¼ in. and thicker, rolled in sheet mills, 21*l.* 15*s.* per ton; black-steel sheets, No. 24 gauge, 22*l.* 15*s.* per ton; and galvanised corrugated sheets, No. 24 gauge, 26*l.* 2*s.* 6*d.* per ton, all for home delivery.

Malleable-Iron Trade.—In the West of Scotland malleable-iron trade there has been no change in the position over the week and makers are all well employed. The orders are sufficient to ensure the continuous operation of plant but there is some shortage of wrought-iron scrap. After an exceptionally busy period the re-rollers of steel bars are now ahead of their commitments and are able to undertake new business for prompt delivery. The tonnage of raw materials on hand is ample for requirements as good supplies of semies have been arriving at the works. To-day's quotations are as follows:—Crown bars, 15*l.* 12*s.* 6*d.* per ton; No. 3 bars, 13*l.* 12*s.* 6*d.* per ton; No. 4 bars, 13*l.* 17*s.* 6*d.* per ton; and re-rolled steel bars, 17*l.* 15*s.* per ton, all for home delivery.

Scottish Pig-Iron Trade.—Very active conditions still prevail in the Scottish pig-iron trade. Steelmakers are pressing for supplies of hematite and basic iron. Deliveries of iron ore are quite satisfactory and good stocks have accumulated. The following are to-day's market quotations:—Hematite, 6*l.* 18*s.* 6*d.* per ton, and basic iron, 6*l.* 0*s.* 6*d.* per ton, both delivered at the steelworks; foundry iron, No. 1, 6*l.* 5*s.* 6*d.* per ton, and No. 3, 6*l.* 3*s.* per ton, both on trucks at makers' yards.

NOTES FROM THE SOUTH-WEST.

CARDIFF, Wednesday.

The Welsh Coal Trade.—Coal-loading operations proceeded throughout the holiday period at the South Wales ports last week. On Good Friday, normal hours of working were observed and the men who actually were on duty were paid overtime in addition to the tariff rates. A similar arrangement was made for Easter Monday. Normal loading conditions came into operation as and from Wednesday. This arrangement came into force as a result of the agreement entered into at the beginning of the war, which greatly extended the facilities available at the docks, particularly at holiday times, and removed one of the greatest causes of dissatisfaction in local coal-exporting circles. A good deal of interest has been evinced in the district during the past week in the demands made by the miners for some effective measure of control of the industry and opposition to the principle of compulsion as applied to the retention in, and the return to, the industry of men unless satisfactory wage standards could be negotiated. This was in reply to the Government's plea for a greatly-increased coal production. It was pointed out that the new wage demand by the miners was in opposition to the agreement reached between the men and the owners at the beginning of the war, under which wages were based on a sliding scale arrangement governed by the cost of living index. When this agreement was reached it was decided that it should remain in force for the duration of the war and for six months after the termination of hostilities. The market continued to display a very favourable tone throughout the week. Sellers, as a rule, had little coal to offer as present productions were largely earmarked for deliveries that were being made under existing contracts. The demand, on both home and overseas account, was actively maintained, but little new business could be arranged for some time to come and the tone was consequently very firm. Dry steam coals were in request by Eireann customers and were fairly active. Best large coals were being steadily lifted and sized sorts were still difficult to obtain for shipment over some little time ahead. Bituminous smalls were only very sparingly available although some of the inferior small grades were still obtainable fairly readily for early delivery. Cokes were active and strong, but patent fuel continued quiet.

The Iron and Steel Trade.—Brisk conditions continued to rule in the iron and steel and allied trades of South Wales and Monmouthshire. The demand was steadily maintained although, with most concerns holding well-filled order books, new business was not easy to negotiate.

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

General Situation.—The heavy output of iron and steel and the large and increasing import of American products have increased supplies to an unprecedented level, but the bulk of the tonnage available is reserved for purposes associated with the war effort. Continued rigid restriction of the use of material for the usual industrial undertakings and careful supervision of distribution, however, promise to relieve the congestion of orders at the works and permit more prompt deliveries to priority users.

Cleveland Iron Trade.—The steadily increasing demand for foundry iron is amply covered, though the parcels of Cleveland pig obtainable are still few and light. There seems no prospects of an early increase in the meagre intermittent make of local foundry iron, but Midland iron stocks are still substantial and satisfactory quantities are regularly arriving from that area for consumption in this district. For particular specified purposes certain qualities of iron are obtainable in adequate quantities from other producing centres. Second-hands have obtained control of an increasing tonnage, but are unable to deal fully with the requirements of their regular customers. The prices of Cleveland pig are based on No. 3 description at 128*s.*, delivered within the Tees-side zone.

Hematite.—The limited production of hematite and the moderate quantities arriving from overseas are barely adequate for current needs and necessitate the rationing of consumers and strict economy in use. Delivery licences are sparingly issued and are granted only to users unable to substitute other iron for the work on which they are engaged. An early improvement in the situation, however, is likely. Conditions in the near future may facilitate an increase in output and permit considerable expansion in the supply of American hematite. The stabilised values are at the level of No. 1 grade of iron at 138*s.* 6*d.*, delivered to North of England customers.

Basic Iron.—Basic blast-furnaces are making sufficient iron for the heavy requirements of the local steelworks, but are providing no tonnage for use elsewhere. The official quotation remains at 120*s.* 6*d.*

Foreign Ore.—Hematite ores are still difficult to obtain, but most other kinds of foreign ore are coming forward regularly. The greatly increased use of native ironstone, in place of material from overseas, has brought into operation plant that has long been idle. Activity at the Cleveland mines is greatly in excess of what was considered possible.

Blast-Furnace Coke.—Business in Durham blast-furnace coke is virtually suspended. The supply is abundant, but holders are extensively sold and local users have covered their requirements as far ahead as they consider advisable. The recognised values are ruled by good medium qualities at 35*s.* 6*d.* f.o.r.

Manufactured Iron and Steel.—The re-rollers of iron and steel have satisfactory stocks of semi-finished commodities and are able to keep their works operating at full capacity. With the exception of heavy joists, all finished products are in increasing demand. There is a strong demand for light rolled material and steel plates for shipbuilding and boiler making, and specifications for railway requisites are being distributed freely. Special alloy steels are all taken up as soon as they become available. Soft steel billets are quoted at 12*l.* 5*s.*; hard billets at 13*l.* 12*s.* 6*d.*; joists and sections at 15*l.* 8*s.*; heavy ship plates at 16*l.* 3*s.*; and heavy rails at 14*l.* 10*s.* 6*d.*

Scrap.—Heavy tonnages of scrap are reaching the iron foundries and steelworks, but consumers are requiring still larger supplies, particularly of heavy grades of both iron and steel, and are anxious to make extensive forward purchases.

THE SOUTH AFRICAN GOLD INDUSTRY.—The production of gold in the Union of South Africa totalled 14,637,741 fine oz. in 1940. This, a record figure, was greater by 1,818,397 oz. than the previous highest total, namely, 12,819,344 oz., reached in 1939.

THE INSTITUTE OF MARINE ENGINEERS.—The associate-membership examination of the Institute of Marine Engineers will be held from May 19 to 24 and on May 26 at centres to suit the convenience of candidates. The graduateship examination (Section A of the associate-membership examination) will be held on May 19, 21 and 23. The common preliminary examinations for admission to studentship of the Institute will be held from April 1 to 5 and from October 7 to 11 at various centres throughout the country. The Lloyd's Register Scholarship examination will be held on May 19, 20, 21 and 23 at centres arranged to suit the convenience of candidates. Full particulars and syllabuses will be supplied on application to the secretary of the Institute.

NOTICES OF MEETINGS.

IT is requested that particulars for insertion in this column shall reach the Editor not later than Tuesday morning in the week preceding the date of the meeting.

JUNIOR INSTITUTION OF ENGINEERS.—*To-night*, 6 p.m., 39, Victoria-street, Westminster, S.W.1. Ordinary Meeting. "Fittings and Their Effect on the Efficiency of Supply Lines," by Mr. S. J. Moore. *Sheffield Section:* To-night, 6.30 p.m., The Sheffield Metallurgical Club, 198, West-street, Sheffield. Informal Discussion Evening, to be opened by Mr. A. V. Jobling. *Institution:* Saturday, April 26, 1 p.m., The Holborn Restaurant, High Holborn, W.C.2. Annual Luncheon.

INSTITUTION OF ELECTRICAL ENGINEERS.—*North-Western Centre:* Saturday, April 19, 2.30 p.m., The Engineers' Club, Albert-square, Manchester. Annual General Meeting. (i) "The Measurement of Lightning Voltage and Currents in South Africa and Nigeria," by Mr. F. R. Perry. (ii) "The Mechanism of the Lightning Discharge and Its Effect on Transmission Lines," by Messrs. C. E. R. Bruce and R. H. Golde. *North-Eastern Centre:* Monday, April 21, 6.15 p.m., The Neville Hall, Westgate-road, Newcastle-upon-Tyne, 1. Annual General Meeting.

INSTITUTION OF CIVIL ENGINEERS.—*Road Engineering Section:* Tuesday, April 22, 5 p.m., Great George-street, Westminster, S.W.1. "Road Traffic Calculations," by Mr. A. J. H. Clayton.

NORTH-EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS.—*Student Section:* Wednesday, April 23, 6.45 p.m., Bolbec Hall, Newcastle-upon-Tyne, 1. "A Few Notes on Mechanical Design for Marine Turbines," by Mr. R. Coates. *Institution:* Friday, April 25, 6 p.m., The Mining Institute, Westgate-road, Newcastle-upon-Tyne, 1. "Plastic Theory: Its Application to Design," by Professor J. F. Baker and Mr. J. W. Roderick.

INSTITUTION OF MECHANICAL ENGINEERS.—Friday, April 25, 2 p.m., Storey's-gate, St. James's Park, Westminster, S.W.1. General Meeting. Informal Discussion on "Mechanical Mishaps," to be opened by Mr. G. E. Windeler.

INSTITUTE OF MARINE ENGINEERS.—Friday, April 25, 2.30 p.m., 83-85 The Minories, E.C.3. Annual General Meeting of the Guild of Benevolence.

THE COATING OF UNDERGROUND PIPES WITH CONCRETE.—An interesting article which appeared in a recent issue of the *Journal of the American Water Works Association* describes the difficulties encountered in towns built on tidal marshes owing to the failure of underground pipe lines running through corrosive soils. The author, Mr. J. H. T. McGee, states that the trouble was overcome by coating the pipes with a layer of concrete having a cement: sand ratio ranging from 1:2½ to 1:4, depending on the condition of the pipes. The Portland cement employed was modified by the addition of not more than 8 per cent. of tricalcium aluminate.

THE "BETHANISING" OF WIRE.—A description of the work done in a wire department of the Bethelehem Steel Company is contained in a recent issue of the United States journal *Steel*. A process termed "Bethanising" is conducted in this department. This consists in depositing zinc electrolytically on the wire, the latter itself being the cathode. The anodes employed consist of a silver-lead alloy and the electrolyte of zinc-sulphate solution. The wire is made to pass continuously through the solution, and the weight of the deposit is accurately adjusted to between 0·4 oz. to 2·4 oz. per square foot by regulating the speed of the passage of the wire through the electrolyte.

COMPENSATION FOR WAR DAMAGE TO ROADS.—At the instance of the Chancellor of the Exchequer, a new clause dealing with compensation for war damage to highways has been inserted in the War Damage Act. The clause proposes that where damage is done to public highways, or to bridges or viaducts carrying them, payments shall be made to highway authorities by the War Damage Commission in accordance with a scheme to be drawn up by the Treasury. The clause further proposes that contributions towards the expenses of making such payments shall be made by county and county borough councils at such rates as may be provided in the scheme. Power is to be given to the Minister of Transport to make grants to councils in respect of their contributions under the war-damage scheme. Such grants, to be paid from the Road Fund, must not exceed one-half of the contributions payable by any council. The scheme to be prepared under this new clause is to be embodied in an Order, which will not be effective until it has been approved by a resolution of the House of Commons. Under the provisions of a money resolution, the grants payable from the Road Fund to local authorities under the scheme are to be met from money provided by Parliament.

THE BONNEVILLE DAM ON THE COLUMBIA RIVER, OREGON, U.S.A.

(*For Description, see page* 301.)

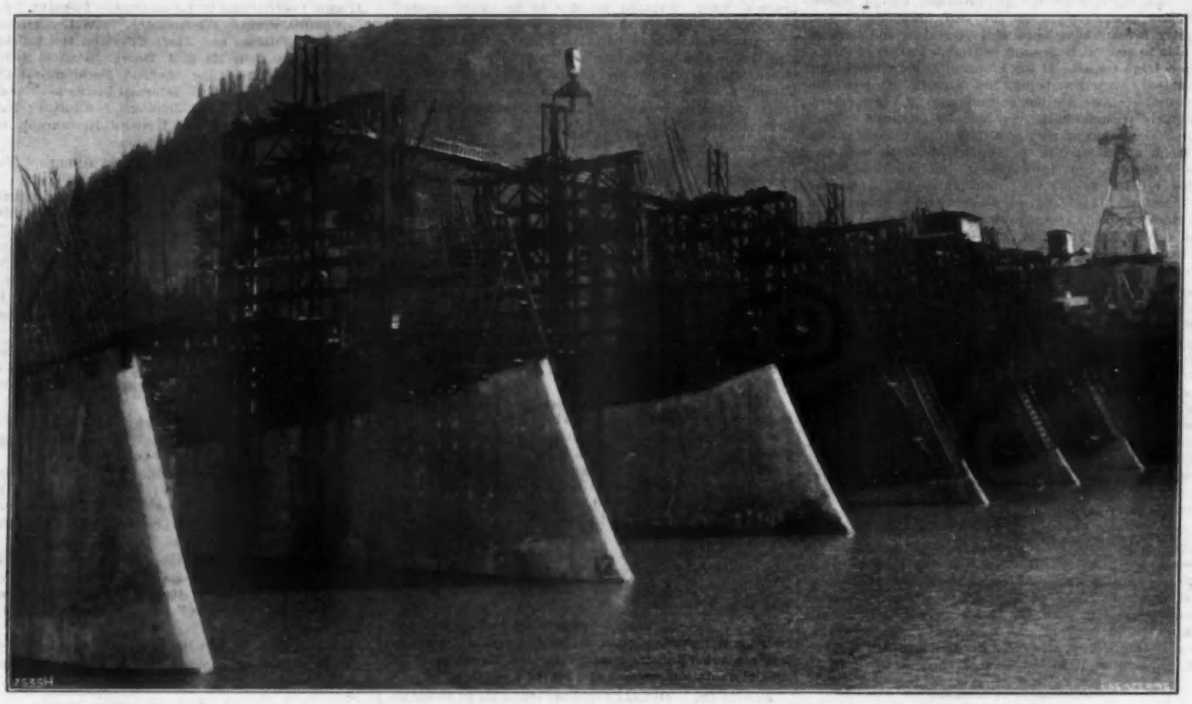


Fig. 8. Partly Completed Piers of Spillway Dam.

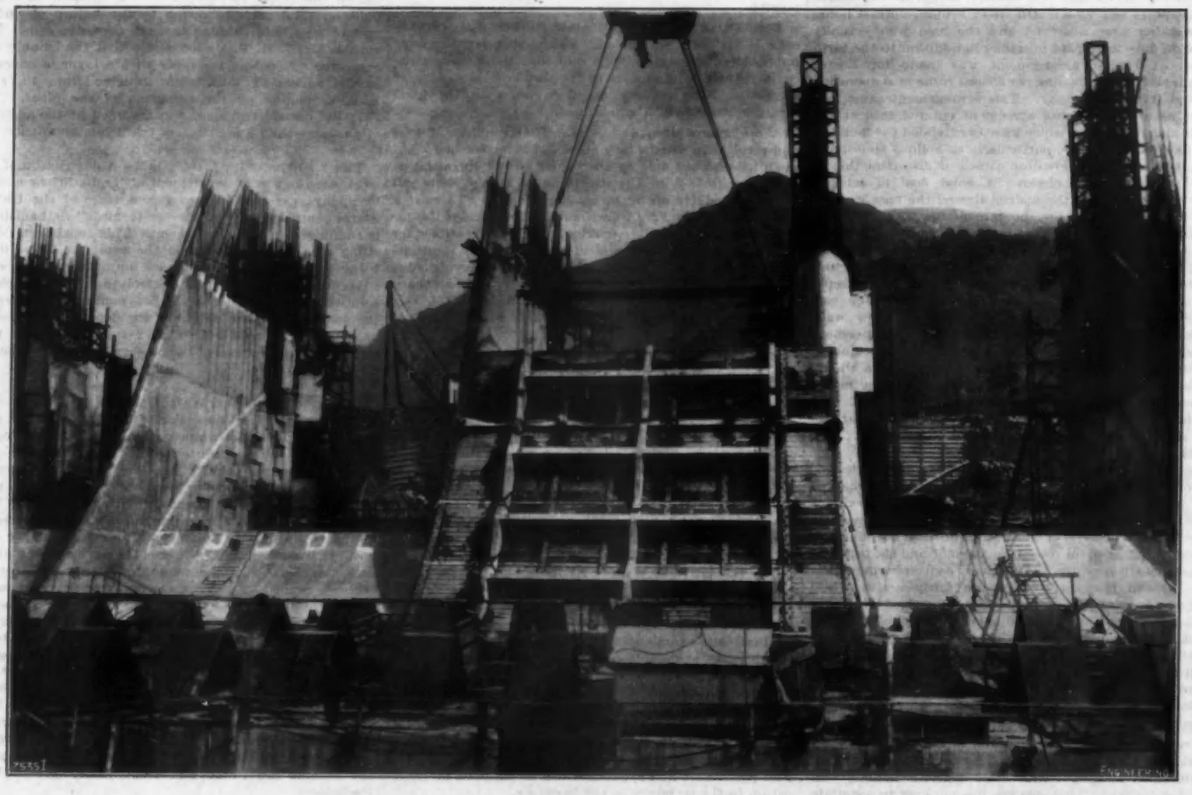


Fig. 9. Spillway Bays with Timber Bulkhead in Position.

THE BONNEVILLE DAM ON THE COL

(For Description, see page 301)

Fig. 4. Downstream View of Spillway Dam during Construction.

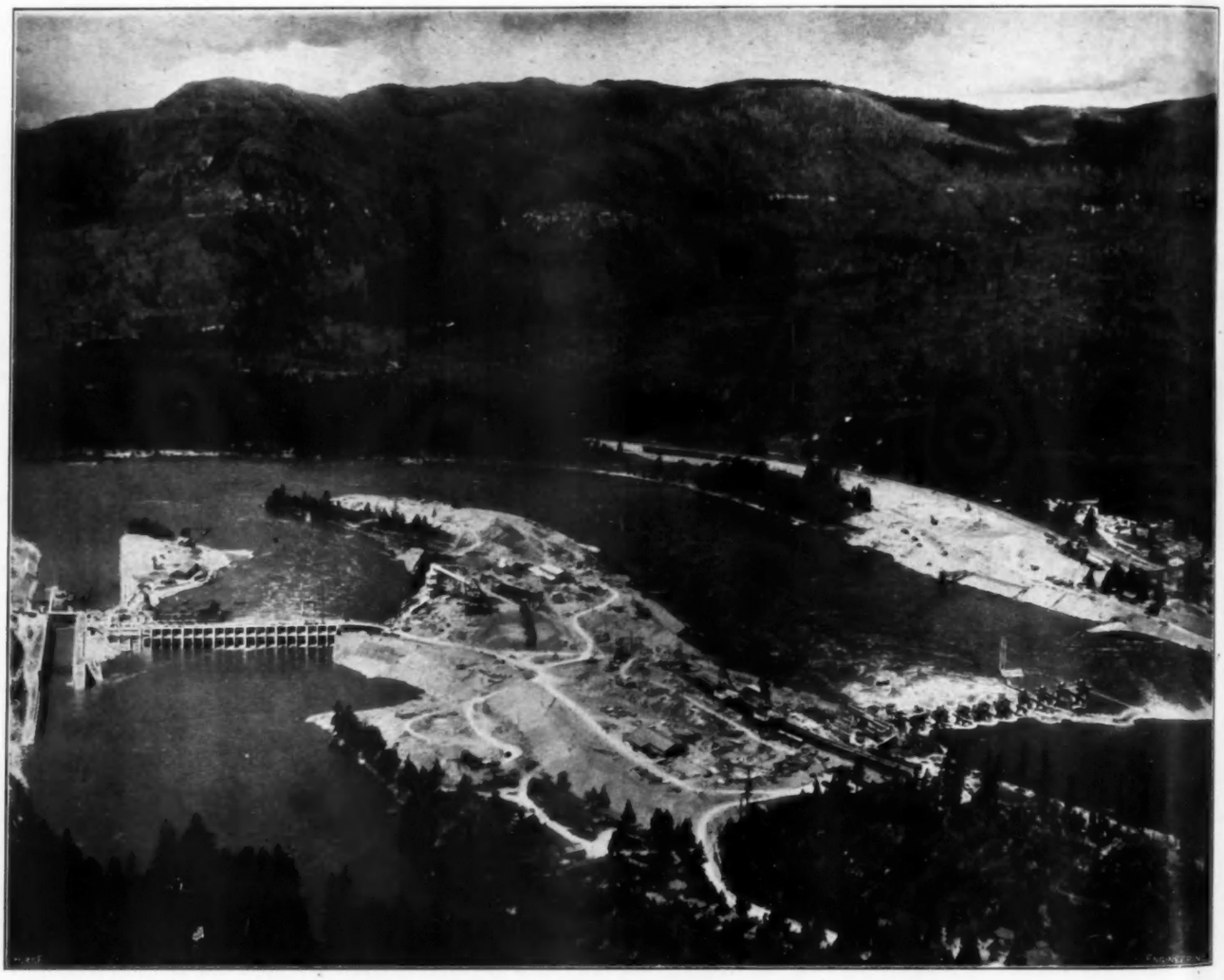


Fig. 6. General View of Bradford Island and Site of Dam.

THE COLUMBIA RIVER, OREGON, U.S.A.

(For description see page 301.)

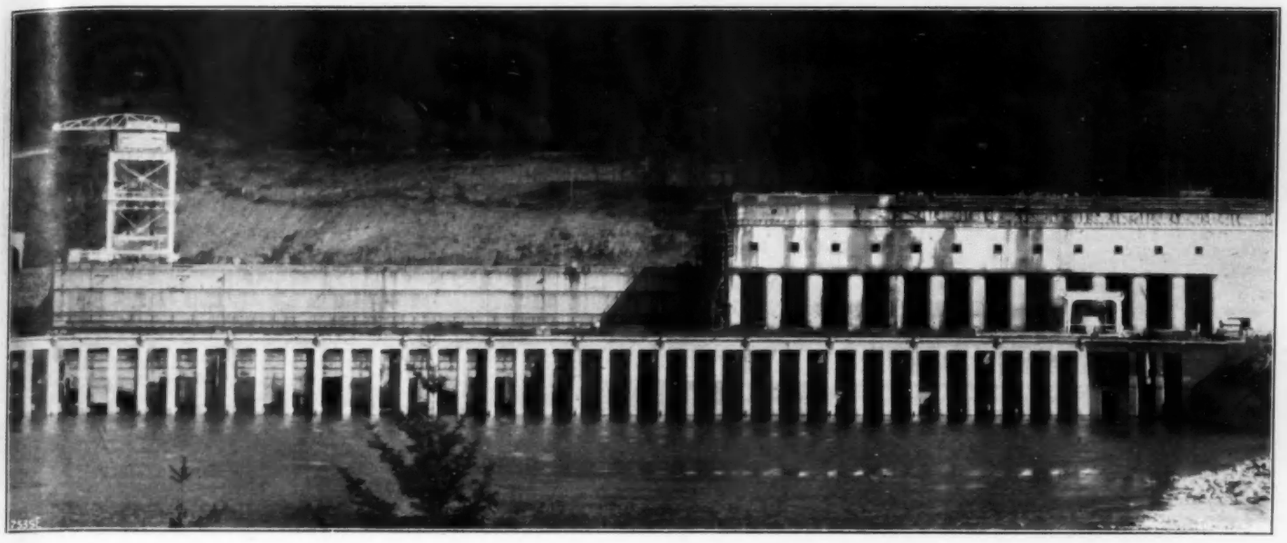


FIG. 5. DOWNSTREAM SIDE OF POWER-HOUSE DAM.

FIG. 7. PIERS AND BAFFLE DECK OF SPILLWAY DAM.

UNIV. OF MICH.

ENGINEERING.

Offices for Publication and Advertisements, 35 & 36, Bedford Street, Strand, London, W.C.2.

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TELEGRAPHIC ADDRESS { "ENGINEERING," LESQUARE LONDON.

TELEPHONE NUMBER—TEMPLE BAR 3663 (2 lines).

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"ENGINEERING" may be ordered from any newsagent in town and country and at railway bookstalls, or it can be supplied by the Publisher, post free, at the following rates, for twelve months (or for six or three months, *pro rata*), payable in advance:—

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TIME FOR RECEIPT OF ADVERTISEMENTS.

Classified advertisements intended for insertion in the current week's issue must be delivered not later than first post on Wednesday. Alterations to standing advertisements must be received at least 10 days previous to the day of publication. Passed proofs must be in our hands by Saturday morning, otherwise they will be taken as correct. The Proprietors will not hold themselves responsible for blocks left in their possession for more than two years.

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TEMPORARY ADDRESS.

For the duration of hostilities, the Editorial and Publishing business of this Journal is being conducted from 18 and 20, Compton Road, Hayes, Middlesex. The Telephone Number of the Editorial Department is Hayes 1730, and that of the Publishing Department, Hayes 1723. The Bedford Street Offices are open on Fridays only, between 10 a.m. and 5 p.m., for the distribution of the current issue and for retail sales.

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One Two-Page Plate.—THE BONNEVILLE DAM ON THE COLUMBIA RIVER, OREGON, U.S.A.

ENGINEERING

FRIDAY, APRIL 18, 1941.

VOL. 151. No. 3927.

THE UNITED STATES OVERSEAS BASES.

THE success which has attended President Roosevelt's policy of strengthening the defences of the United States is an indication of some relaxation in the isolationist attitude which has dominated the affairs of that country for many years. The public contention that no commitments shall be undertaken which might involve the United States in another European war shows little weakening, but the ready acceptance of the new defence measures indicates a growing realisation of the fact even that country cannot act as a self-contained unit indifferent to the proceedings of the rest of the world. Although the United States at war with a great European power would be in a very different position from that now occupied by Great Britain, even she is dependent on outside supplies for some vital materials, of which manganese, tin and rubber are important examples. Her position in this respect was dealt with in an article in these columns in our issue of October 11, 1940. Apart from this aspect of the matter, some of the incidents of this war have shown that attacks on her shipping, and even on her littoral, might inflict important damage and suffering, and seriously hamper her trade. Further, she cannot afford to be indifferent to the fate of her overseas territory, of which the Philippine Islands forms the most important example.

Although it need in no way be considered as an emergency policy, it is clear that the agreement for the lease of naval and air bases in British territory to the United States, which was signed on March 27, owes its consummation directly to the recent proceedings of Germany and Italy. As yet, the bases exist only on paper—perhaps have not even got that far—and it would have been well had the understanding they represent been come to years ago as one aspect of a common strategy. Although the war has drawn the United States and the British Empire into closer alliance than ever before, they have had mutual interests, from the point of view of defence, for many years. This is illustrated by the case of Newfoundland, which has been left entirely unprotected, except that there is a relatively small Canadian naval base at Halifax, some 700 miles away. From St. John's, Newfoundland, to Brest, is about 2,300 miles, easily within raiding distance for a cruiser squadron, as the recent exploits of the Gneisenau and Scharnhorst have shown and, it is obvious that in the past the defence of this island, *de facto* if not *de jure*, has been largely left to the United States. It is not suggested that there has been any commitment, but from the time of President Monroe it has been clear that the United States is not prepared to stand aside and watch the landing of overseas hostile forces in any part of the American Continent.

The choice of Newfoundland as the site of one of the new bases is not to be taken as evidence of a direct American desire to strengthen the defences of that island and of Canada. The position has been selected as the most westerly available in the North Atlantic. The main industrial and political part of the United States lies in the north east. This is at present protected by naval bases at Boston, New York, Philadelphia and Norfolk, of which the last is the most important. Boston, the most northerly, has an adequate naval yard, but no facilities for the operation of a military air force. Although an attack on the north-east littoral by a major fleet appears improbable at the moment, it is necessary in any wise strategic plan to make provision for the possible as well as the probable. Actually, such an eventuality is well covered by the existing naval bases, especially as the attacking force would necessarily be operating more than 3,000 miles from its home ports. This, however, does not rule out the possibility of attack by high-speed raiding forces and the air outpost in Newfoundland, 900 miles from Boston, would prove of great value both for reconnaissance and for hampering and possibly damaging the enemy. Since the signing of the agreement with this country, the United States, last week, made a treaty with the Danish Minister under which she will construct air bases in Greenland. This will extend the control which can be exercised from Newfoundland and is further evidence of determination to accept responsibility for protection of the whole American continent.

An air force stationed on Bermuda, the site of another of the bases, would be capable of rendering similar service to those located in Newfoundland and Greenland. This island, which is about 650 miles from the American coast has, however, other potentialities. It has a British garrison and fortifications, but is not protected on the scale which one may assume is contemplated in connection with the construction of the new base. As its capture would give an enemy an admirable position from which to harry United States ocean and constwise shipping, it is not surprising that it has been chosen as one of the new protected outposts. Both this war and the last have emphasised the importance of doing everything possible to prevent the enemy from establishing overseas submarine and fuelling stations.

Jamaica, Antigua, St. Lucia, Trinidad, and British Guiana, the sites of the remaining bases, all lie on the eastern approaches to the Panama Canal. Although the United States has not to protect such widespread territory as has the British Empire, she has long coastlines and extensive interests in both the Atlantic and Pacific oceans. The present state of world affairs shows that a combination against her of Germany, Italy and Japan is not an impossibility. It is not likely that she would have to face such a triumvirate alone, and, in any case, some of the partners to it have been recently mauled, but, as already said, a wise strategy must see farther than next year or the year after, and the maintenance of the best possible communication between the Atlantic and Pacific oceans must remain a fundamental necessity in her naval policy.

From the dockyard at Norfolk, Virginia, to Puget Sound, in the State of Washington, the main naval base on the Pacific, is some 6,300 miles via the Panama Canal, as compared with 15,000 round South America, though the Straits of Magellan. The importance of this difference, should it be necessary to transfer the fleet, or part of the fleet, from one ocean to the other in war time, must result in the maintenance of the Panama Canal route forming a cardinal point in policy. Apart from fleet move-

ments, freedom for shipping carrying supplies in war may be scarcely less important. The canal itself is strongly fortified, but this provision does nothing to protect its approaches. Lying as it does at the south-west corner of the Caribbean Sea, the Atlantic entrance to the canal is sheltered by the group of islands constituting the West Indies, which sweep round from the tip of Florida through Cuba, Haiti, Puerto Rico, and the Leeward and Windward Islands, to Trinidad, off the coast of South America.

There are three northern approaches through these islands: the Yucatan Channel, between Cuba and the mainland; the Windward Passage, between Haiti and Cuba; and the Mona Passage between the latter island and Puerto Rico. For the protection of these routes to the canal, the United States relies in the main on the naval base at Guantanamo, which it leases from the Cuban Government. It is situated close to the Windward Passage, which forms part of the direct route from the eastern American seaboard to Panama. A fleet stationed at Guantanamo could exercise control over a large part of the Caribbean Sea. As Puerto Rico and the island of St. Thomas, at its eastern end, are United States possessions, seaplane bases or naval outposts might be constructed on them to extend the area of control. In the eastern approaches to Panama, however, through the maze of islands forming the Lesser Antilles, the United States has no footing. The islands are distributed between British, French and Dutch ownership. As the route from South America to Panama passes through the archipelago, and as it offers numberless possibilities for the establishment of commerce-harrying bases by an enemy power, the situation has not been very satisfactory in view of modern developments. The new leased bases at Antigua, St. Lucia and Trinidad, which are fairly distributed throughout the islands, will greatly increase the possibilities of effective control. The matter has been rounded off by the lease of a further base at Jamaica, well inside the Caribbean Sea, and an outside position in British Guiana from which South American shipping can be more effectively protected against raiders.

The Pacific end of the canal, lying at the north of the Gulf of Panama, is well protected by powerful fortifications against direct attack, but there are no outlying stations for the protection of shipping. We have no possessions in that area, but the Galapagos Islands, belonging to the Republic of Ecuador, might form a possible base for hostile craft and the lease of a base in them by the United States would appear no less important than the arrangements she has made with Great Britain in the West Indies. That extension of defensive, and, if necessary, offensive positions into the Pacific is considered necessary has been made evident by the decision to fortify the Island of Guam, which is situated about 1,400 miles east of the Philippine Islands and 1,600 miles south of Japan. The protection of this island is at present provided by the powerful naval base in Hawaii, which, however, is nearly 4,000 miles away. Guam would form a useful outpost in time of war, and, if possible, it is desirable that its capture by an enemy should be prevented, or, at least, delayed.

Although the country would not desire even a small and unimportant island to be occupied by an enemy, the most serious United States responsibility in the Eastern Pacific is undoubtedly constituted by the Philippine Islands, which occupy a most vulnerable position west of the Japanese mandated islands and some few hundred miles south of Formosa. The United States has a naval base at Manila, but as under present constitutional arrangements the Philippine Islands will become an independent country in 1946, that base would presumably have to be abandoned. In view of recent experiences and the present international situation, it appears probable that some arrangement for the retention of the Manila base under lease will be made, but a more satisfactory procedure would be for the United States to retain some form of suzerainty over the Philippines. This is a matter in which, again, the interests of the United States and the British Empire march in common. The Philippine Islands, with the Manila base, in the hands of a hostile power would greatly facilitate offensive action against Singapore.

RECONSTRUCTION AND PHYSICAL PLANNING.

When the Great Fire of 1666 swept away a large part of what is now the City of London, the civic authorities of the time were fortuitously offered a great opportunity, which, however, they neglected to embrace. Instead of rebuilding the city on a well-devised plan, they allowed reconstruction to take place on the original building lines, and, in so doing, perpetuated a network of narrow and inconvenient alleys, which, though of interest to antiquarians, are a loss of time and money, and a source of many other inconveniences to their everyday inhabitants. Thanks to enemy action, a similar opportunity is offered to the civic authorities of London and other populous parts of the country; and the question is being generally asked, whether history will repeat itself or whether wiser counsels will enable something positive to be done to rebuild the devastated areas on more modern lines. If these questions are to be answered as they should be, not only London, but every similarly congested area in the country should be considered. This introduces many complications. Since the Great Fire, London has grown from a small town surrounded by a series of villages, whose principal means of inter-communication was still the river, to an enormous conglomeration of brickwork and concrete, inhabited by millions of people, traversed by a widespread network of roads and railways, and supplied with water, gas and electricity in a profusion undreamt of in the days of Charles II, from a number of centres through systems of mains which are only paralleled in complexity by the similar system of drains and sewers which carry away its waste. On a smaller scale, this picture is reproduced in Birmingham, Liverpool, Manchester, Glasgow, Newcastle, Hull and many other parts of the country. All these centres of population and industry have suffered from the attention of the enemy to a greater or lesser degree, and the authorities in all of them are, therefore, faced with the direct problems of reconstruction and planning.

In dealing with these problems, either on paper or in actual practice, it is desirable that a distinction should be drawn between their two categories. Everyone interested has probably some idea in his own mind of what is implied by the words "reconstruction" and "planning," even though enough care is not always taken to remember that they are not necessarily the same thing. Exact definition is, however, another matter. For the purposes of the present argument, we may consider that "reconstruction" should be used only in the sense of replacement, without taking into account such factors as new building lines or improved designs, not to speak of more esoteric matters, such as site values and compensation. Similarly, "planning" should be used when the question is one of dealing with an area that has been wholly or partly denuded of its buildings, and using the cleared site as a basis on which to erect something better and more efficient than that which has been destroyed.

That this view has some support is clear from a significant occurrence which took place at a recent conference at the Ministry of Works and Buildings. At this meeting the names were announced of the members of a consultative panel which has been appointed to assist the Ministry in solving some of the problems at which we have hinted above. The title suggested for this body was Consultative Panel on Reconstruction, but as a result of some direct comments made by those present, this was altered then and there to "Consultative Panel on Physical Planning," which more accurately indicates its scope. It is not going too far to suggest that this is a change of fundamental importance. The public, no more than the experts, does not want mere reconstruction, if by that is meant the perpetuation of what experience has shown it would be advisable to replace by something better. Neither do either public or experts want mere planning if the term is merely to mean what Lord Reith has called drawing-board work. They require rather the preparation of a concrete scheme, which taking into account every relevant factor, should have as its object the planning of a layout which will improve the health of the population, their capacity for work, enhance their pleasures, and generally provide conditions which will lead to a brighter and more efficient existence.

To approach such an ideal is not going to be easy: the path is beset with many obstacles and pitfalls. In the first place, physical planning in the broadest sense involves matters which are at present dealt with by more than one Government department. Town planning, to use a familiar, if not fully understood, term, is controlled by the Ministry of Health, as are housing in the more limited sense, water supply and the siting of civil aerodromes. The location of industry and gas supply, come under the Board of Trade, electricity supply under the Electricity Commissioners, and much factory legislation under the Home Office. The new Ministry of Works and Buildings, in addition to being given responsibility during the war for the erection of all civil works and buildings required by the Government and for determining the priority of proposals for reconstructing buildings damaged by air raids, has been charged with the task of instituting research into the use of building materials and more recently, with the main problem of planning. There will be every temptation, therefore, for the departments to engage in internecine warfare. Though it is to be hoped that this will be strongly resisted, the temptation may be unwittingly increased by the large number of professional and amateur bodies which are concerned with various aspects of the problem, and even by the public interest which it has attracted. To overcome this difficulty, the importance of which must not be ignored, it is evident that a Central Planning Authority will necessarily have to be constituted.

Already, we understand, consideration is being given to the question of how this authority should be constituted and what its responsibilities should be. These are obviously matters which must be settled at an early stage. It is also desirable that, in addition to the Central Authority, there should be regional authorities who, from their local knowledge, would be capable of filling in details in a general plan, in accordance with the conditions present. The existing local authorities would work under these bodies on bold and comprehensive lines so as to produce, for a given area, the plan which will offer the greatest prospects of success. In certain districts, a start has already been made in this direction. Test surveys have been undertaken in the Coventry, Birmingham and Bristol areas, while, as we announced last week, the London County Council and City Corporation are engaged on a plan for London and the surrounding area. It is hoped that these plans will be shaped on the broadest possible lines, such matters as the approval of the extension of city boundaries being assumed, if such an extension seems necessary for carrying out the desired improvements. The legislative and administrative difficulties of giving effect to any plan will have to be studied in relation to such important matters as the payment of compensation and the recovery of betterment in respect of public control of the use of land. It is hoped that the report of Mr. Justice Uthwatt's committee, on these subjects will soon be available and that, as a result, legislation will be quickly introduced to put a stop to speculation in site values and to deal with immediate difficulties with regard to temporary building in bombed areas.

Enough has been said to show that reconstruction and physical planning are two problems which demand the closest consideration and that in this consideration something much more than mere replacement will be required. There must necessarily be legislative and contemplative, as well as material, clearance and disturbance, and above all, there must be a whole-hearted and general determination to provide a proper foundation for the new structure. If that aim is achieved, in spite of those conscious and unconscious obstacles which we fear will undoubtedly be found in the way, the widespread destruction which has been caused by enemy action, much as it is naturally to be deplored on every ground, will at least be shown to have its compensations and to have inspired some contribution to the cause of progress in this important sphere of civilisation.

NOTES.

THE BUDGET AND STABILISED PRICES.

THE natural tendency of the taxpayer to regard the Budget from the point of view of how it will directly affect his own pocket may tend to obscure what has been correctly described as its most important single proposal. During the coming months, direct taxation will weigh even more heavily than it has done during the past year. These imposts will, however, be borne cheerfully to ensure victory; and the more so when the motive behind the purely financial measures is understood. This motive is the prevention of inflation. When it is remembered how many perilous steps we made towards that precipice and how our present enemy slid over the edge 20 years ago, it will be agreed that no measure is too drastic to ward off this catastrophe. To avoid any such disaster it is necessary that the gap between revenue and home expenditure should not be allowed to widen. One of the ways of doing this is to prevent any serious increases in the prices of essential goods and services, increases which would inevitably be followed by demands for rises in wages and the beginning of what is picturesquely known as the vicious circle. The Chancellor of the Exchequer is, therefore, to be commended for his intention to take steps to continue and extend the policy of stabilising prices in an endeavour to prevent any further rise of the cost-of-living index number above the present range of 125 to 130 in terms of the pre-war level. This will mean that the Exchequer will bear the increases that are already due in shipping charges, including freight rates and insurance premiums. The question of how far further increases in railway rates and fares may be averted is also being examined. If such a check can be devised, individuals and traders will be relieved of a burden the uncertainty of which has been not the least part of its weight and once again the upward movement of prices will be avoided. This general policy of restricting increases in prices to a minimum is also to be applied to the prices of coal, gas and electricity, which, although they do not actually figure in the calculation of the cost of living index, ought obviously to be treated in the same way as other charges. Finally, the Chancellor has said that it will be his aim, in conjunction with the President of the Board of Trade and the Minister of Food, to try to prevent substantial increases in the prices of other articles in common use. It can hardly be doubted that this is the right policy, even though the financial purist may complain that a liability the extent of which cannot be estimated is being assumed.

LICENCES FOR BUILDING OPERATIONS.

THE Ministry of Works and Buildings has announced that, as from April 14, there came into force an important amendment to Regulation 56A of the Defence (General) Regulations, which concerns building operations. Under this amendment, no building operation estimated to cost more than 100*l.* may be commenced except by licence issued by the Ministry or, in the case of local authorities and public utilities, by an authorisation issued by the appropriate Government department. The term "building operation," it is stated, includes decorative work and also work in connection with water, lighting, heating and other services; and the restriction applies to the aggregate cost of all such operations undertaken, or proposed to be undertaken, in respect of a given building within any period of 12 months. Works carried out by, or at the expense (wholly or in part) of a Government Department, or by a local atthority under the Civil Defence Acts of 1937 and 1939, are excluded from the operation of the Order, as they are already subject to control by the departments concerned. Whether the main purpose of the amendment is to reduce the demands on the available labour, with a view to releasing man power for other work; or to restrict the consumption of materials—most of which are already controlled to vanishing point, so far as the private purchaser is concerned; or to limit the spending of money which otherwise might be invested in Government securities, is not clear; but the effect is evident enough. Not only will much necessary maintenance work be greatly hampered, if not prohibited, but there appears to be considerable danger that urgent repairs to damaged property, industrial as well as private, which local authorities are too hard-pressed to sanction or assist, and which owners are willing and anxious to undertake on their own responsibility, may also be delayed even more than is the case at present; with the result that the actual depreciation will exceed more than ever the maximum allowances permitted. No indication has been given that any extension of the supervisory staff of the Ministry has been arranged, or what degree of decentralisation is contemplated, to enable applications for licences to be dealt with promptly; but the matter is one of such importance to owners of property of all kinds that the need for a fuller pronouncement on these and associated points is urgent.

THE CRYSTAL PALACE.

By the time that these Notes appear in print, the second of the Crystal Palace's long familiar towers will have been demolished and no more than foundations, wreckage and a few outbuildings will remain of the building which has been so long a familiar landmark of South London. The contract to demolish the towers was given to Messrs. George Cohen, Sons and Company, Limited, last year, but it is only recently that the piecemeal demolition of the south tower has been undertaken. The north tower, which stands (or stood) on a less restricted site, is being felled by explosives. The towers did not form part of Paxton's original Great Exhibition building, but were added by I. K. Brunel in 1855, after the removal of the main building to Sydenham, for the purpose of supplying water under pressure to the fountains in the Palace grounds. The height of the towers from ground level was 284 ft., and they rested on concrete foundations 60 ft. in diameter and 3 ft. deep, which supported circular walls of brickwork laid in cement, 56 ft. in diameter and 18 ft. in depth. In the centre of each tower, a brick shaft served the double purpose of carrying off smoke from the boilers in the base, and forming the core of a spiral staircase connecting the various floors. The annular iron tanks, each holding over 1,500 tons of water, were built of boiler plate and were carried on wrought-iron girders, radiating from the central shaft and supported on the external ring of iron columns. The pumping engines for the fountains were of 320 h.p., and circulated the water through some 10 miles of pipes, ranging in diameter from 3 ft. to 1 in. The North tower also contained a Waygood water-balanced lift, which made an ascent of 181 ft. in about 30 seconds. A separate water supply was provided for the lift by electrically-driven pumps. We understand from Messrs. Cohen that the demolition of the towers will contribute some 1,600 tons of iron to the national salvage effort.

POST-WAR EMPLOYMENT PROBLEMS AND THE ELECTRICAL INDUSTRY.

A good deal is heard from the publicists of the courage, amounting almost to indifference, with which the public is withstanding the stress of war-time conditions, and there is no doubt that if even heavier burdens have to be shouldered the necessary steadfastness to bear them will also be forthcoming. Among these manifestations of the national spirit one of the most significant is, perhaps, the constant concern which is shown with what are conveniently called post-war problems. Mr. H. Joseph, for instance, speaking at a luncheon of the South Midland Centre of the Institution of Electrical Engineers, on Saturday, March 29, speculated on whether we should not be faced with severe unemployment when the production of armaments ceased and when millions of young men returned from military service. This, he said, would be one of our greatest problems and he hoped that the necessary finance would be available and the requisite initiative forthcoming for the large programme of reconstruction and development, both at home and abroad, which would not only be necessary in itself, but would also serve to alleviate unemployment. In any such programme, the electrical industry would, of necessity, play a major part. An important part, he suggested, would be contributed by the electrification of the railways and the development of local underground railways in the large provincial cities. It was, perhaps, a little unfortunate that the scheme for the improvement of factory lighting had been introduced just now as a war measure. It would certainly tend to increase production, but there were neither men nor materials to spare in these days for more than a fraction of this programme and he felt that it might have been better to have left this and similar reforms for post-war days, to help to fill the gap in employment which would inevitably occur. Many other developments would undoubtedly take place and in all of them electricity would necessarily play an important part.

UNEMPLOYMENT AND THE WAR EFFORT.

The figures issued by the Ministry of Labour this week show that the war effort is having an increasingly potent effect in reducing unemployment. The number of men and boys registered as wholly unemployed on March 17 was 172,660, a decrease of 44,856 compared with February 10. Of this total, moreover, 36,408 had been classified by interviewing panels as unsuitable for ordinary industrial employment. This figure is so large that it would seem that the irreducible minimum of unemployed is being approached and that it will only be possible to maintain the output of munitions by transferring men and women from other activities or by utilising the services of those who, for one reason or another, have hitherto not been in employment at all. There is plenty of evidence to show that more could be done in this way and the necessary steps should, therefore, engage the urgent attention of the Minister. That the problem is pressing is also shown by the fact that those registered as on short-time or otherwise temporarily suspended from work on the understanding that they were shortly to return to their former employment only numbered 41,676; this was a decrease of 27,741 compared with the number announced on February 10. Those registered as unemployed casual workers, being persons who normally seek their livelihood by jobs of short duration, numbered 17,000, an increase of 415 compared with the month before. The corresponding figures for women and girls at March 17 were 191,648 wholly unemployed, of whom 2,001 had been classified by interviewing panels as unsuitable for ordinary industrial employment; 34,015 temporarily stopped; and 919 unemployed casual workers. Compared with February 10, the numbers wholly unemployed showed a decrease of 39,781; those temporarily stopped a decrease of 10,803; and unemployed casual workers a decrease of 135. The greatest fall in unemployment occurred in the London area, where the decrease was 22,236. This was followed by Scotland, with a fall of 13,539; by the Northern and Welsh divisions, with falls of 12,836 and 12,097, respectively; and by the North Eastern and North Midlands with 11,841 and 10,096. In the Midlands the decrease was 9,956, in the North-Western area 8,586, and in the South-Western and Southern areas 5,921 and 4,590, respectively. It is pointed out that the figures for the London, Southern and South-Western areas are not strictly comparable with those of previous months as there has been some re-arrangement of the areas in these divisions.

SHIPPING LOSSES.

The official decision, announced on April 15, to publish the figures of shipping losses at monthly intervals, instead of weekly as hitherto, is not altogether surprising in view of the virtual impossibility of ensuring immediate accuracy at such short intervals. Time after time, it has been necessary to issue corrections of totals previously announced, sometimes after a lapse of several weeks; usually because some ship or ships, though overdue, could not be definitely regarded as lost, and, occasionally, because ships had made port when hope of their survival had been abandoned. This has been a serious objection against the weekly totals, hardly less serious than the contrasts which sometimes appeared between good weeks and bad. Monthly returns will afford a truer view of the position.

OBITUARY.

SIR H. NIGEL GRESLEY, C.B.E.

IN last week's issue of ENGINEERING we referred very briefly to the great loss that locomotive engineering had sustained by the death, on April 5, of Sir H. Nigel Gresley, C.B.E., D.Sc., chief mechanical engineer of the London and North Eastern Railway since the constitution of that system in 1922 and, previously, since, 1911, of the Great Northern Railway. As was explained in our paragraph, the advancement of our normal schedule, necessitated by the Easter week-end, made it impracticable to deal then with the many outstanding features of Sir Nigel Gresley's career, which has been described by a recent writer as having no parallel in British locomotive history. The following notes may, perhaps, indicate in some measure the influence that he has exerted on the development of steam locomotive practice in this country during the past 30 years.

Herbert Nigel Gresley was born on June 19, 1876, and was the fourth son of the Rev. Nigel Gresley, rector of Seale, in Leicestershire, and grandson of Sir William Nigel Gresley, of Drakelow, Derbyshire, 9th holder of a baronetcy created in 1611. He was educated at Marlborough and, on leaving school, in 1893, was apprenticed to Mr. F. W. Webb at the London and North Western Railway works at Crewe. On the conclusion of his apprenticeship in 1897, he remained for a year at Crewe as a fitter and then proceeded to the Horwich works of the Lancashire and Yorkshire Railway, to serve a two years' pupilage under the late Sir (then Mr.) John A. F. Aspinall. At its termination, in 1899, he was appointed test-room assistant to Aspinall, but occupied this post for a short time only, being transferred to Blackpool early in the following year as running-shed foreman. This appointment also was of short duration, for, later in the same year, he was made one of the outdoor assistants in the Carriage and Wagon Department. A year later he was transferred to the Newton Heath carriage and wagon works of the Lancahire and Yorkshire Company as assistant works manager, becoming works manager in 1902, and, in 1904, assistant superintendent at Newton Heath. This was rapid promotion for a young man still in his twenties. Gresley was not yet thirty when he left the Lancashire and Yorkshire Railway to become Carriage and Wagon Superintendent of the Great Northern Railway, at Doncaster, where, six years later, he succeeded the late Mr. H. A. Ivatt as chief mechanical engineer.

The first locomotives produced at Doncaster under the Gresley regime were 0-6-0 goods engines of the class now known as the "J6," but they were virtually an Ivatt design, and the first that could be regarded as wholly "Gresley" were the 0-6-0 mixed-traffic engines of what is now the "J2" class of the London and North Eastern Railway. These were followed, in 1912, by the 2-6-0 engines, with boilers 4 ft. 8 in. in diameter, which he designed mainly for fast goods traffic. By this time it could be said that he had found his feet as a locomotive designer, and the 2-8-0 engines, which appeared in 1913, and the more powerful Moguls of 1914, with 5-ft. 6-in. boilers, demonstrated that Ivatt's successor possessed both courage and competence to restore to the Great Northern the reputation for originality which had seemed to be slipping away from it.

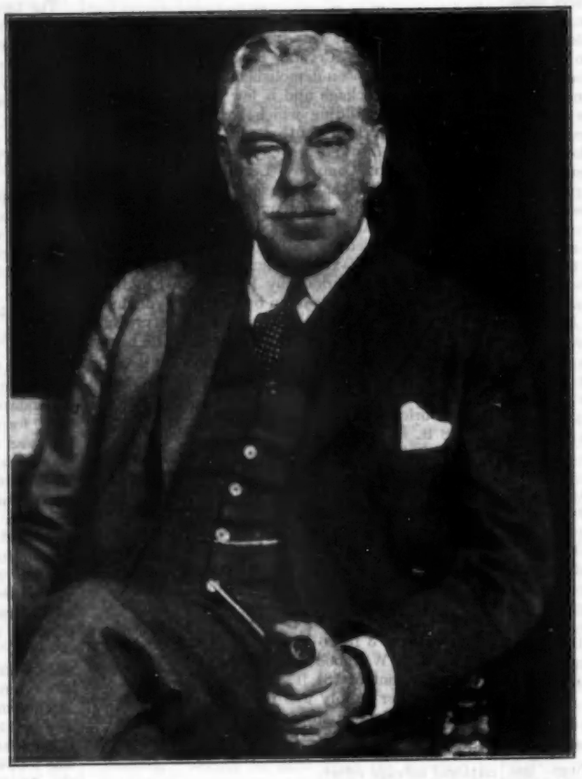


Photo: Bertram Park.

THE LATE SIR H. NIGEL GRESLEY, C.B.E.

The outbreak of war in 1914 somewhat retarded the developments planned for the express passenger locomotive stock of the Great Northern system, but they proceeded steadily, concurrently with the extension of superheating and the production of new classes of tank and other engines for various duties, which, however, can be no more than mentioned in passing. In 1915, one of the Ivatt Atlantics was rebuilt as a four-cylinder simple engine, with Walschaerts valve gear for the outside cylinders, but a rocking-shaft gear, driven from it, operating the valves of the inside cylinders. This was the forerunner of the Gresley gear, since standardised on the L.N.E.R. for the various classes of three-cylinder locomotives that have proceeded from the Doncaster works since 1918, when the first engine so fitted—a 2-8-0—was built. The gear was described and illustrated in ENGINEERING of April 25, 1924, and in a paper on "Three-Cylinder High-Pressure Locomotives,"* which Mr. Gresley (as he then was) delivered at the summer meeting of the Institution of Mechanical Engineers, at Newcastle-on-Tyne, in 1925. The motion of the centre valve-spindle is derived from that of the two outside spindles by means of two cross-levers of unequal length. The short one is attached to extensions of the centre and left-hand spindles and thus is a floating lever. The long lever is pivoted at a fixed point and has arms of lengths in the ratio of 2 to 1, the long end being joined to the right-hand spindle extension and the short end to the centre of the floating lever. The combined action of the two levers gives the centre spindle a movement equal in magnitude to that of the outside spindles and 120 deg. out of phase with them. Various modifications of the motion are in use, but the principle is the same in each case. It was pointed out at the meeting that a gear similar in principle had been designed in 1909 by Mr. Holcroft, of the South Eastern and Chatham Railway; but in fact, Mr. Gresley stated, he was unaware at the time of this earlier gear, which was used, apparently, on one engine only, for experimental purposes, and employed a different arrangement of levers.

The steady progress made in the improvement of the Great Northern's locomotive stock during the first ten years of Gresley's direction had established his position in the eyes of his professional contemporaries, but in 1922 he attracted a much wider attention to the railway and, inevitably, to himself, by bringing out the first of his 4-6-2 (or "Pacific") express engines. At that time, the 4-6-2 wheel arrangement was represented in this country only by Churchward's "The Great Bear" of 1908, on the Great Western Railway, which had not been conspicuously successful. Gresley's No. 1470 ("Great Northern"),† however, made locomotive history almost at once by hauling a test train of 600 tons weight with evident ease, thus setting a standard of performance which the subsequent engines of this type have more than maintained. The "Flying Scotsman" of this class was the principal exhibit by the L.N.E.R. at the British Empire Exhibition at Wembley in 1924. Sundry modifications were introduced in subsequent series of the class, chief among them being an increase in working pressure from 180 lb. to 220 lb. per sq. in., the fitting of larger superheaters, and, in 1935, streamlining; but the main design has remained substantially the same, and more than 100 of the type have been built. The 100th Pacific, put into service in 1937, was fittingly named "Sir Nigel Gresley."

Following the railway grouping of 1922, Gresley

* See ENGINEERING, vol. 120, page 58 (1925).
† *Ibid.*, vol. 113, page 454 (1922).

was appointed chief mechanical engineer of the London and North Eastern Railway, and, for the next few years, was occupied with the considerable undertaking of "rationalising" the many and diverse types which had characterized the Great Central, Great Eastern, Great Northern, North Eastern, Great North of Scotland, Hull and Barnsley, North British, and various smaller railways that had been absorbed into the L.N.E.R. This process more or less completed, he was able to turn again to new development and, in 1929, brought out the interesting, though unsuccessful, 4-6-4 four-cylinder Yarrow-boilered locomotive, No. 10,000, in which the working pressure was 450 lb. per square inch.* It was eventually rebuilt as a three-cylinder simple engine, with a boiler of the "Green Arrow" type, working at 250 lb. per square inch.† Another experiment of about the same period was the fitting of Lentz poppet-valve gear to two 4-4-0 engines of the "D.49" class‡ instead of the usual piston valves. Poppet valves were also fitted in the small but notable class of 2-8-2 ("Mikado") engines, headed by the "Cock o' the North,"§ which were introduced in 1934 to handle heavy passenger trains over the severe gradients between Edinburgh and Aberdeen. These were the first British eight-coupled express locomotives and proved to be very successful. Later engines of this type were provided with streamlined casings. Mention was made in our description of the new "Bantam Cock," a fortnight ago, of the 2-6-2 "Green Arrow" class of mixed-traffic engines of 1936,‖ which, like the "Cock o' the North," were the first tender engines of their wheel arrangement to be employed on British railways.

All of these were technical achievements which, did space permit, would deserve and receive fuller treatment; but they must be subordinated to the more spectacular work of Gresley's "peak" years, 1935 to 1938, which saw the introduction of the "Silver Jubilee" and "Coronation" streamlined expresses, and a series of remarkable speed records, culminating in the attainment of a new world speed record, for steam traction, of 125 miles an hour. The genesis of the "Silver Jubilee" was told by Sir Nigel himself in 1936, in his presidential address to the Institution of Mechanical Engineers.¶ During a visit to Germany in 1934, he had been impressed by the smooth running of the "Flying Hamburger" at 100 miles an hour, and invited the builders of it to estimate for a similar train for his own railway. Neither in accommodation nor estimated performance, however, did the German design show any advance over existing L.N.E.R. practice, and Gresley therefore set himself to accomplish what the German engineers appeared unable to do. The train was built at Doncaster in the short space of five months, and, on September 30, 1935, it commenced regular running between London and Newcastle (268 miles), with one intermediate stop, in an overall time of 4 hours.

The success of the "Silver Jubilee" was immediate, and some outstanding performances were recorded with several of the "A.4" Pacifics from time to time; notably the 113 miles an hour reached by No. 2512, "Silver Fox," on August 27, 1936. The public response was such that, in 1937, the coronation year of King George VI, the company instituted a second high-speed service, the "Coronation," making the daily journey of 392½ miles between London and Edinburgh, in each direction, in an overall time of 6 hours.** The two capitals already possessed a unique train service in the non-stop "Flying Scotsman," made possible by Gresley's device, unique in railway practice, of the corridor tender, enabling engine crews to be changed *en route*. The working of these very fast trains raised some difficult problems of signalling and braking, and it was in the course of some high-speed braking tests, on July 3, 1938, that the locomotive Mallard, No. 4468, with a train of 240 tons (including the dynamometer car), maintained an average of 120 miles an hour for 5 miles, over 123 miles an hour for nearly two miles, and, for a short time, exceeded 125 miles an hour. Meanwhile, it may be observed, the "Silver Jubilee" and the "Coronation" ran steadily to their schedules with a remarkable regularity that the public very soon took for granted; in its way, probably, an even more noteworthy achievement than that of the world speed record, and one which alone amply merited the degree of D.Sc., *honoris causa*, conferred upon Sir Nigel in 1936 by the University of Manchester.

Sir Nigel received his knighthood in the same year, in recognition of his services as chairman of the committee set up, in 1935, by Sir Walter Runciman, as President of the Board of Trade, to consider the types of steering gear fitted in the steamers Usworth and Blairgowrie, which had been lost at sea, apparently as a result of failure of their steering gear. He had been awarded the C.B.E. in 1920 for his work during the war of 1914-18, when the Great Northern Railway works at Doncaster were largely engaged on the manufacture of munitions. Other Government committees on which he served were those appointed by the Ministry of Transport to consider automatic train control, and the electrification of railways. He had also been, for many years, a governor of Queen Mary College (formerly the East London College), and a lieutenant-colonel in the Engineer and Railway Staff Corps, R.E. (T.F.).

As previously mentioned, Sir Nigel Gresley was president of the Institution of Mechanical Engineers in 1936. He had joined the Institution as member in 1907 and had served on the Council since 1924. In addition to the papers already cited, he delivered one in 1931 on "Locomotive Experimental Stations," a subject in which he took a keen interest. It will be a matter for general regret that he did not live to see the completion of the joint testing station, for the establishment of which he pressed so long and urgently. He was also a member of the Institution of Civil Engineers and, in 1922, was awarded a Telford Gold Medal for a paper on "Trials in Connection with the Application of the Vacuum Brake for Long Freight Trains," which he presented in collaboration with the late Sir Henry Fowler. He was a member, too, of the Institution of Electrical Engineers, the Institute of Transport, and the Institution of Locomotive Engineers, and occupied the presidential chair of the last-named institution in 1934. He took out a number of patents, but, as this summary of his career indicates, he was less an originator than an improver. No man kept a more careful watch upon the trends of locomotive development in all the great railway-operating countries, or showed a more balanced critical faculty in selecting those ideas and principles which offered the most promise, combining their good features and correcting their defects until he produced results that the most sanguine of their initial sponsors scarcely would have dared to predict. Such an alliance of judgment and technical modernity is much rarer than mere originality; but, when it does occur, the ultimate extent of its influence is hardly to be foreseen.

* ENGINEERING, vol. 128, page 850 (1929).
† *Ibid.*, vol. 144, page 682 (1937).
‡ *Ibid.*, vol. 129, page 39 (1930).
§ *Ibid.*, vol. 137, page 621 (1934).
‖ *Ibid.*, vol. 141, page 704 (1936).
¶ *Ibid.*, vol. 142, pages 489 and 541 (1936).
** *Ibid.*, vol. 144, page 40 (1937).

COMMUNICATIONS TO BRITISH CHAMBERS OF COMMERCE OVERSEAS.—British Chambers of Commerce overseas have drawn the attention of the London Chamber of Commerce to the fact that they frequently receive inquiries from their members in the United Kingdom giving very scanty details of requirements, with the result that it is necessary to write to Britain for further particulars. It is emphasised that the delays which may affect overseas mails in war time make it more than desirable that all relevant information should be given in the first instance, as otherwise the business may be held up for several months.

FARADAY HOUSE SCHOLARSHIPS.—As a result of the entrance-scholarship examinations, held at Faraday House Electrical Engineering College on April 1, 2 and 3, Mr. K. H. Parrish, of Acton Technical College, was awarded the Faraday Scholarship of 80 guineas a year, tenable for two years in the College and one year in one of the works affiliated with the College. Mr. D. L. Harding, of King's College School, gained the Maxwell Scholarship of 60 guineas per annum, tenable for two years in the College and one year in a works, and Mr. J. L. Harland, of King's School, Canterbury, was awarded an exhibition of 60 guineas a year, tenable for one year in the College and one year in a works.

LETTER TO THE EDITOR.

TOOL DYNAMOMETER FOR MEASURING RAPID FORCE FLUCTUATIONS.

TO THE EDITOR OF ENGINEERING.

SIR,—We have read with great interest the article "Tool Dynamometer for Measuring Rapid Force Fluctuations," by Dr. Arnold, appearing in your issue of March 21, on page 221. Scratch extensometers of the type used by Dr. Arnold for measuring these forces are invaluable for investigating varying stresses in many complicated structures; we consider, however, that the results should be interpreted with great care and discretion. We have frequently used scratch extensometers of the De Forest type ourselves; in these, the scratch arm has been dipped in a bituminous plastic containing carborundum grit.

The average of carefully-made calibrations of a number of these scratch extensometers, each working on a 2-in. gauge length (the normal distance between points of attachment of the two parts of the extensometer to the stressed member) have shown that (1) extensions up to 13×10^{-6} in. on the 2-in. gauge length were not scratch-recorded, (i.e., a strain of $6{\cdot}5 \times 10^{-6}$ in., equivalent to 0·85 ton per square inch stress in steel when E = 13,000 tons per square inch, or equivalent to 0·2 ton per square inch stress in Elektron metal where E = 3,040 tons per square inch). (2) Extensions greater than 13×10^{-6} in. were recorded, but the *difference* between the height of the scratch and what it should have been (*a*) was only $8{\cdot}3 \times 10^{-6}$ in. when the true extension was 25×10^{-6} in. (*b*) increased slowly from this minimum value to 13×10^{-6} in. as the true extension increased to 174×10^{-6} in. (3) There was close consistency among the calibrations made.

It would be interesting to learn whether Dr. Arnold has calibrated his scratch extensometers and whether he has taken the calibration into consideration in his article. Bearing in mind the above, the vertical scales of forces in the diagrams of Plate XVII do not suggest this; in which case, they will not be correct. The traversing of the scribing arm across the record strip, and hence the inclination of the lines forming the record, are controlled by (*a*) the springing effort at the fulcrum in the scribing arm; (*b*) the frictional forces haphazardly occurring between the arm and the metal record-piece. The distance between any two points of zero-recorded strain on the base-line of the record is purely defined by (*a*) the inclination of the lines of the record; (*b*) the magnitude of the intervening maximum strain recorded.

As Dr. Arnold points out, the horizontal scales (time) of the records are quite erratic; we consider that they merely permit the sequence of recorded strains to be reviewed. We often wish that the records were traced relative to a proper time-base, but the simplicity of the instrument goes far towards compensating for this disadvantage.

Yours faithfully,
J. C. LOACH,
J. O. COWBURN.

Research Laboratories,
L.M.S. Railway,
Derby,
April 12, 1941.

THE INSTITUTION OF ENGINEERS AND SHIPBUILDERS IN SCOTLAND.—Mr. F. C. Stewart has been elected President of the Institution of Engineers and Shipbuilders in Scotland, for the session 1941-42. Dr. A. McCance and Sir Stephen J. Piggott have been elected vice-presidents.

THE HAULAGE OF LIME AND BASIC SLAG.—As a result of representations made by the British Road Federation, the Land Fertility Committee has decided that, in view of increased road-transport costs, it will admit as eligible for contribution, under the Ministry of Agriculture Land-Fertility Scheme, charges for the haulage of lime and basic slag, by road, which do not exceed by more than 25 per cent. the rates set out in the schedule agreed between the Land Fertility Committee and the road motor-transport industry.

INTERCHANGEABILITY OF MARINE MOTORS.

By Kyrle W. Willans, M.I.Mech.E.

It seems beyond question that the cost of repairing high-speed compression-ignition engines, as fitted to modern motor vehicles, is less, per hour run, than is the case with the lower-speed compression-ignition engines fitted to fishing boats. It might be expected that the contrary would obtain, as, in addition to other problems, that of road shocks is not present at sea. However, the fact remains that repair bills take a good deal of the savings effected by low fuel consumption, while, unless piston rings are maintained in good order, lubricating-oil consumption has a habit of rising with disconcerting rapidity.

There is, however, one fundamental difference between the running of a compression-ignition engine in a lorry and its fellow in a boat, namely, that, in the case of the lorry, the water temperature is kept high, while in the boat it is low. There being a definite temperature at which the best results are obtained, it is evident that the boat engine will suffer by reason of running well below that temperature. The remedy, of course, is to depart from orthodox marine practice, and adopt the more correct plan of closed-circuit cooling, with fresh water as the cooling medium and salt-water circulation to control the water temperature.

By using this system, not only will hot water be available for radiators and other purposes, but, at the same time, the circulating pump becomes a simple impeller, to speed up the rate of flow of the circulating water, and the problems of strainers, and circulating-pump glands and valves, are diminished. The effect, of course, is that the special marine engine becomes virtually the standard lorry engine, apart from problems connected with the reverse gear, and bilge and salt-water circulating pumps.

It is obvious, however, that it would be all to the good to make the boat engine identical with the lorry engine, especially from the point of view of maintenance costs; so let us remove the reverse gear from the engine, and drive the bilge pump from the reverse gear instead of from the engine. The higher speed of the lorry engine entails the use of a reducing gear, but that is becoming standard practice in any case, and therefore is no problem. Reverse-reduction gears of the S.L.M. type have certain definite advantages as regards durability, to say nothing of the way in which they facilitate the fitting of adequate engine bearers.

We may visualise, therefore, in the future, the installation of a sub-base carrying the reverse gear. The reverse gear will embody the bilge and water-circulating pumps, both of which can draw from the bilges if need be, and the connection from the reverse-gear input shaft to the engine will be through a flexible coupling. By the use of the flexible coupling and sub-base, the problem of alignment of engine and reverse gear is materially simplified; so much so that the changing of an engine is a matter of an hour instead of several days, always provided that the skylight over the engine is designed to enable the engine to pass through it, if not horizontally, at any rate on end. Suitable eyebolts at the correct points would make the lifting of the engine a simple matter. The only connections to be broken will then be those between the engine and the cooling system, the fuel pipe from service tank to engine, and the engine exhaust. If the facings for these pipes could be arranged in the same position on all engines, the problem would be a simple one.

Although the phrase "all engines" refers to all engines of one particular make, there is no reason, apart from the disinclination of competitors to do so, why all engines, of whatever make, should not have certain fixed dimensions for engines of similar powers and speeds. If the dimension from crankshaft centre to bottom of sump, the pitch and number of holding-down bolts, distance of holding-down bolts from crankshaft flange face, and the positions of exhaust-pipe outlet facing, and water-circulating flow and return facings were the same for all engines, any engine of a given power and speed could be made to fit on any sub-base.

At first sight, it would seem a big request to make to the engine builders; but, admitting this to be the case, the alternative would be that any one firm taking up the system, and succeeding (as it undoubtedly would) in giving users better overhauling at lower prices, would collect a very large proportion of the business available. From the users' point of view, and from that of methodical improvement based on users' experience, it would be most advantageous if all the well-known engine builders made a standard model (say, 120 brake horse-power at 1,600 r.p.m.) embodying the special features of each make, but capable of being installed on a standard sub-base, and connected to a standard reverse-reducing gear.

No provision has been suggested for driving a winch off the engine. The writer holds this to be a most improper way of driving a winch; bad both for the winch and the engine. The same principle can be followed, however, with the auxiliary engine; that is to say, it can be made subject to a standard set of dimensions, so that any make can be fitted to one bed.

Again, by standardising the reverse-gear ratios, and the centres between input and output shafts, makers could fit their gears to certain standard beds. It would seem, however, that the shipbuilder would tend to become the main contractor, fitting reverse gears and sub-bases to fishing craft, at any rate, and leaving the owner free to fit any of a certain number of engines, with ability to change his engine for another make at some future date without modification to boat or fittings.

The advantage to both owner and engine builder of the use of an absolutely standard lorry-type engine cannot be overstressed. Reconditioning could be done on shore, under proper conditions, and there would be none of the exasperating delays accompanying repairs done in the boat; all too frequently hastily done under the stimulus of an impatient owner who wants to get to sea, and frequently resulting in further breakdown, loss of time and increase in bills.

It seems abundantly clear that to get the best out of a compression-ignition engine it should be overhauled systematically after so many hours service. Good running is mainly a matter of clearances; if those clearances are maintained correct, running expenses will be low. Finally, by the method outlined, spare engines, properly reconditioned, could be kept available all round the coast, and fitted as required, by the minimum of staff, with maximum of expedition.

MATERIALS FOR ELECTRICAL CONTACTS.

(*Continued from page 286.*)

Among the noble metals which have been proposed for contacts, the small group comprising palladium and ruthenium needs special consideration. These metals do not tarnish or oxidise at room temperatures, but are liable to become covered with oxide films if heated to temperatures within the range from 350 deg. to 900 deg. C. At higher temperatures the oxides decompose. For these reasons, palladium is not quite so good a tarnish-resistant as platinum, but is, nevertheless, better for use in sulphurous atmospheres than the metals described below. Contact alloys, which fall in the same class, include the 40 per cent. copper-palladium, 50 per cent. silver-palladium, and 10 per cent. and 14 per cent. ruthenium-platinum alloys. If the surfaces of any of these materials become heated locally some slight increase in contact resistance may be expected. The remaining noble metal, silver, (generally known in industry as fine silver, to distinguish it from the alloy of silver with 7·5 per cent. of copper, called standard or sterling silver), is in a class by itself. It does not develop oxide films at room or elevated temperatures, and in many atmospheres it remains bright and untarnished for months. It is, however, attacked by most sulphur compounds and then becomes covered with a brown or black film, which considerably increases the contact resistance. Although a fine-silver contact may give excellent service in one locality, it will rapidly tarnish elsewhere. In spite of this, fine silver is used for many light-duty applications with complete success. It should, however, be emphasised that fine silver must never be used in equipment containing ebonite or vulcanised rubber. Rubber-covered wiring, though it varies somewhat in its potency, is particularly liable to cause sulphur tarnishing in a most virulent form. In one experiment a short length of rubber-coated wire was sealed in a tube with a pair of silver contacts. After heating to 100 deg. C. for 4 hours, the resistance between the silver contacts was found to be 16 ohms.

The sulphur-tarnishing characteristics of fine silver are not improved to any appreciable extent by alloying small quantities of more noble metals with it. Although it is sometimes considered that the widely-used alloys of silver with 5 per cent., 10 per cent., and 20 per cent. of palladium or 5 per cent., 10 per cent., and 20 per cent. of gold resist tarnishing better than silver, the improvement is negligible. There is, however, a marked improvement when atomic parts of noble metal are added (37 per cent. by weight of palladium or 52 per cent. by weight of gold). Complete resistance is not generally reached until 50 per cent. atomic of noble metal is added. The alloys containing 50 per cent. palladium and over appear completely resistant to sulphur and 30 per cent. palladium is the minimum which will produce any appreciable improvement. Among the remaining commonly used contact metals, the most important are tungsten and the powder-metallurgy products containing tungsten, molybdenum or nickel. All these are liable to become coated with high-resistance oxide films and are not generally suitable for light-duty work. If they are used for this application the contact pressures should be as high as possible.

In light-duty contacts dust and grease films are far more often responsible for failure than is generally realised. Hairs or dust particles are frequently invisible and occasionally become embedded in the contact surface. Troubles from dust are most serious when the contact pressure is small or the currents are so minute that they are unable to burn away or are across the small gaps produced by these semi-insulators. In the author's opinion, films of foreign matter are also responsible for the high resistance faults encountered in what is known in the telephone industry as "dry" contacts, *i.e.*, in contacts carrying very small alternating current without any superimposed direct current. In these conditions, the effect is that, as the voltage is increased slowly from zero, the current is at first only a minute fraction of the value to be expected, but when the voltage reaches a certain point the contacts cohere and the current jumps to its full value. The author has never been able to reproduce this effect with carefully cleaned, freshly prepared contact surfaces, but it appears that high resistance must be due to the formation in service of some feebly-conducting surface film. Suggestions have been made that gas layers are responsible for high-resistance contacts, and oil or grease may also be a cause of the trouble. In some preliminary tests a number of contacts were maintained in the open position in a closed case above a bath of liquid paraffin with the object of ascertaining whether an adsorbed layer might form on the contact surfaces. No increase in contact resistance was noted, however, between contacts of fine silver, platinum, 40 per cent. silver-palladium, or 10 per cent. iridium-platinum after six weeks exposure.

Films of foreign matter are undoubtedly also the cause of many of the instances of mysterious contact failure frequently quoted in the literature of the subject. One example is the case of a steel ball 5 mm. in diameter, which rested under its own weight on a flat steel plate and was said to have withstood an applied electromotive force of 100 volts without conducting. When freshly cleaned and de-greased materials were used the contact resistance was only 0·25 ohm. As the ball only weighs 0·57 gramme, it is obvious that the presence of a few particles of dust would be sufficient to prevent metallic contact. In order to reduce dust troubles to a minimum, the following steps should be considered: the use of as high a contact pressure as possible and of highly-polished contact surfaces with at least one dome-shaped contact; and the use of "twin contacts," *i.e.*, two separate contacts on each spring, at least one spring being split in order to distribute the pressure between the two contacts; the use of tightly-fitting dust covers; arranging contact springs as far as possible in the vertical plane; avoiding the presence of moving parts which cause dust disturbance; and eliminating rubbing action between ebonite and similar stop materials which may generate dust. So far as the choice of contact material is concerned, it would seem that, other factors being equal, the one with the hardest surface is to be preferred as most likely to retain its hard polish. There are grounds for believing that the very hard brightly-polished surfaces produced by rhodium plating remain particularly free from dust and dirt films, but accurate comparison between different materials is lacking.

The most serious types of failure when the current is sufficiently large to cause arcing or sparking is that caused in direct-current circuits by the action known variously as "building up," "carry-over" or "material transfer." As a consequence of this action, serious variations in the length of the contact gap may be

caused or the contacts may even become interlocked. Symmetrical alternating currents are less damaging to the contacts and do not produce serious material transfer. This phenomenon has received considerable study. Much of the experimental work has, however, been confined within a very limited range of current and voltage. As a result, it is extremely difficult to correlate the results and to reconcile conflicting statements even on so fundamental a question as the direction of transfer. The author therefore puts forward the following general description with some reserve:

At least three sets of conditions appear to exist and to determine the extent and character of transfer in contacts interrupting direct-current circuits. In the first place, when the current is small and below a critical value, which depends on the voltage at break and the nature of the contact material, no appreciable transfer is observed. As a first approximation the critical value of current is that at which arcing first occurs. With smaller currents some sparking may be produced, particularly at high voltages or in inductive circuits, but this may be considered to involve no volatilisation of the contact materials. The spectra of sparks produced in these conditions show that the lines are independent of the nature of the contact tips. With these small currents, however, material may be transferred from the positive to the negative contact, due to the movement of positive space ions at the instant when the contacts are separated by 10^{-4} to 10^{-5} cm. This is presumably the "flow-discharge" type of reverse transfer which has been observed when interrupting currents of $\frac{1}{2}$ ampere in a circuit of 50 volts containing an iron-cored inductance of about 1 henry. Gold and high-gold alloys are said to show the effect to the most pronounced extent, silver to a certain degree, and platinum very slightly. In the author's experience, reverse transfer occurs only within a very limited current range just below the limiting value at which arcing commences. It is never large in amount and has never been observed to be a cause of contact failure. Appreciable reverse transfer has, however, been reported when currents of several amperes (but below the arcing value) are interrupted at low voltages.

When the limiting current is exceeded and arcing occurs, metal is transferred from the negative to the positive contact. With fine silver, when the limiting current is only just exceeded, "build up" may take on a most extraordinary character. A long thin spike grows on the positive contact and a corresponding cavity is produced on the negative. Spikes as long as 0·1 in. and only 0·01 in. in diameter have frequently been observed, while the corresponding cavities appear as if drilled with a needle cleanly through the negative contact. Sometimes the spikes break off and then do little damage, but they usually grow rapidly until they interfere with the free movement of the contacts and cause failure after a short period of operation. When higher currents are broken, greater amounts of material are transferred, but these are usually distributed over a larger area of the contact face. As a result, the deposit on the positive contact becomes more domed, while a shallow crater is formed on the negative. Owing to the change in the nature of the build-up, a contact may actually operate for a longer period without locking with these higher currents than with a current only just above the limiting value. There are grounds for believing that positive transfer takes place when the contacts are separating. In one experiment, two relays were set to operate in turn, and so connected that the contacts in one interrupted the circuit and those in the other were responsible for the make. No conclusions could be drawn from the behaviour of the making contacts owing to the inevitable presence of contact bounce. The other contacts, however, which gave a clear-cut breaking action, exhibited characteristic transfer when currents above the limiting value were handled. It may, therefore, be accepted that whatever may occur at make, normal transfer can occur at break. It has been claimed that the principal cause of positive transfer is the formation of a small molten bridge of metal just before the contacts finally separate. The evidence for the formation of these molten bridges rests mainly on observations on contacts which were separated very slowly, and it may be questioned whether it has been conclusively established that a similar action always occurs in rapidly operating contacts. It seems probable that while molten bridges form in some conditions with certain metals, the effects of volatilisation and oxide films have an important influence on the mechanism of transfer.

A third type of transfer is recognised as occurring in circuits in which the contacts are shunted by a condenser. With this arrangement there may be a large current range when the condenser is short-circuited at make and this produces, in effect, a small spot weld. In these conditions, the negative contact may pick small particles from the surface of the positive contact when the weld is broken and produce an appearance of negative transfer.

(To be continued.)

LABOUR NOTES.

THE latest issue of *The Ministry of Labour Gazette* states that in the industries covered by the Department's statistics, the changes in rates of wages reported to have come into operation in Great Britain and Northern Ireland during February are estimated to have resulted in an increase of about 193,500*l.* in the weekly full-time wages of 1,980,000 workpeople and in a decrease of about 7,300*l.* in those of 197,000 workpeople. Of the 197,000 workpeople whose rates of wages were reduced, the great majority had received an increase of greater amount in January. The particulars given of the numbers of workers affected and the amount of the changes in weekly wages exclude changes affecting Government employees, agricultural labourers, shop assistants and clerks for which classes the information available is not sufficient to form a basis for statistics.

Of the estimated total increase of 193,500*l.* a week, about 121,500*l.* was due to arrangements made by joint standing bodies (including 74,500*l.* under cost-of-living sliding scales arranged by such bodies); 14,650*l.* was due to the operation of other sliding scales based on the cost of living; 50*l.* was due to the operation of a sliding scale based on selling prices; 26,500*l.* was due to an arbitration award; and the remaining 30,800*l.* was the result of direct negotiations between employers and workpeople or their representatives. The whole of the estimated decrease of 7,300*l.* a week was due to the operation of sliding scales based on the proceeds of the coal-mining industry. The changes reported in the first two months of 1941 are estimated to have resulted in a net increase of about 670,000*l.* a week in the full-time wages of 5,100,000 workpeople and in a net decrease of 300*l.* in those of 6,000 workpeople. In the corresponding two months of 1940, there were net increases estimated at 700,000*l.* in the weekly full-time wages of nearly 4,750,000 workpeople and net decreases estimated at 3,600*l.* in those of about 140,000 workpeople. The foregoing estimates of the effects of the changes on weekly wages are based on normal conditions of employment and do not take into account the effect of overtime working, etc.

The principle groups of workers affected by the wage changes in February were those employed in pottery manufacture, iron and steel manufacture, ready-made and wholesale bespoke tailors, building, civil-engineering construction and gas and electricity supply. Pottery workers received increases of 4*d.* a day for men, 3*d.* a day for women, and 2*d.* a day for juniors. Workpeople employed in iron and steel manufacture in various districts received increases of 0·8*d.* a shift in the case of men and 0·4*d.* a shift in the case of youths and boys. The rates of wages of workpeople employed in ready-made and wholesale bespoke tailoring were raised by 1*d.* and $\frac{1}{2}$*d.* an hour for men and women, respectively. Building-trade operatives and men employed by civil-engineering contractors had their wages advanced by $\frac{1}{2}$*d.* an hour. Gas workers received an increase of $\frac{3}{4}$*d.* an hour or 6*d.* a shift, and workers employed by electricity-supply undertakings had their war bonus increased by $\frac{1}{2}$*d.* an hour in the case of men, with proportional increases in the case of youths and apprentices.

Other groups of workers whose rates of wages were increased included ironstone miners and limestone quarrymen in various districts, heavy chemical workers in certain establishments, tin-plate workers, women and girls in the engineering industry, woollen operatives in the West of England, jute workers, workpeople employed in the sugar-confectionery and food-preserving trade, tobacco workers, coopers, and manual workers employed in the non-trading departments of a large number of local authorities. The decreases in rates of wages affected coal miners in Yorkshire, South Derbyshire, Leicestershire, Cannock Chase and North Staffordshire, and were due to the operation of sliding scale agreements under which wage rates vary in correspondence with fluctuations in the ascertained proceeds of the industry.

The number of trade disputes involving stoppages of work reported to the Ministry of Labour and National Service as beginning in February was 60. In addition, eight disputes which began before February were still in progress at the beginning of that month. The approximate number of workpeople involved in these 68 disputes (including workpeople thrown out of work at the establishments where the disputes occurred) was 13,000, and the aggregate duration of the disputes in February was about 23,000 working days.

In March, the home-branch membership of the Amalgamated Engineering Union increased from 464,713 to 477,768, and the Colonial-branch membership from 41,510 to 42,656. The number of members in receipt of sick benefit decreased from 6,928 to 5,967, and the number of superannuated members from 13,375 to 13,327. On donation benefit there were 465, as compared with 382 a month earlier, and the total number of unemployed members was 2,048, as compared with 1,974.

Mr. Tanner, the president of the Amalgamated Engineering Union, states in his report of the executive council's proceedings in March that on several occasions the employers have complained as to the delay which takes place in the operation of the Relaxation Agreement and "urged the simplification of the procedure." "Arising from the experience of the past months," he records, "and the discussion which took place with the Engineering and Allied Employers' National Federation in March, 1941, the executive council has now approved modifications which have been embodied in an agreement entitled "Temporary Relaxation of Existing Customs as to Employment of Skilled Men, Members of the Amalgamated Engineering Union."

The text of the agreement with the Engineering and Allied Employers' National Federation is as follows:—"With a view to facilitating the operation of the agreements of August 28, 1939, and September 11, 1939, relating to the temporary relaxation of existing customs entered into between the parties, it is mutually agreed (1) a change of practice, for which application has been made by an employer, shall be put into operation after the acquiescence of the shop stewards, or, where shop stewards have not been appointed, the appropriate representatives of the workmen involved in the department concerned, has been obtained, without the necessity of prior reference to the Local Joint Relaxation Committee. (2) The registration of a change of practice approved as in Clause 1 above shall be endorsed by an employers' representative and a union representative on the Local Joint Relaxation Committee. A meeting of the Local Joint Relaxation Committee shall not be deemed necessary for such endorsement unless discussion of the registration in question is desired by either party."

Details of the agreement between the Engineering and Allied Employers' National Federation and the Amalgamated Engineering Union on the subject of the wages of apprentices, youths and boys were given recently in these Notes. The agreement—which is given in full in the April issue of the Amalgamated Engineering Union's *Journal*, contains these two clauses: (2) "There shall be no alteration of piecework prices unless they do not yield to the worker of average ability at least 25 per cent. on the new basic rate. (2) In the case of pieceworkers, the appropriate national bonus shall be based on the pieceworkers' national bonus."

The committee of coal-owners and miners' representatives, the Mines Department of the Government, and the executive committee of the Mine-workers' Federation appear to have been in more or less close consultation during the past week. On Thursday, the executive of the Mineworkers' Federation, after discussion with the Mines Department, adopted the following resolution:—"We note the decision of the Government to introduce the Essential Work Order on mutually arranged terms and agree to inform the Minister that the federation calls for the collaboration of the Mines Department towards the establishment of a national board with power to consider wages or other matters affecting the industry."

A statement issued by the Ministry of Transport last week informed the dock workers on Clydeside that despite their decision not to operate the new Government labour plan, the scheme would come into force on Tuesday this week. Speaking in London, Lieut.-Col. Moore-Brabazon, Minister of Transport, said that the scheme was working well at Liverpool, but in Glasgow opposition to it came from people who thought he was not serious. The new system would start definitely on Tuesday, whatever anybody on Clydeside said or did not say.

The Unemployed Insurance Statutory Committee, in its annual report, recommends that 38,587,007*l.* of the balance of the general account should be used to extinguish the Fund's debt, and that the remainder of the balance and all the balance of the agricultural account should be carried forward. Seven years ago, the amount of the debt was 105,780,000*l.* At the end of 1940, there was a credit balance of 54,534,577*l.* on the general account and one of 3,858,294*l.* on the agricultural account. The income of the general account was 67,103,434*l.* and exceeded the expenditure of the year by 33,979,355*l.* The income of the agricultural account at 1,252,575*l.* was 461,072*l.* in excess of the expenditure.

PROXIMATE ANALYSIS AND COAL BEHAVIOUR.*

By J. G. Bennett.

In engineering practice there are many survivals which once represented the best scientific thought of their day, but are now known to be defective. It is not always easy to discard such survivals when no satisfactory alternative is readily available, especially if they retain a considerable practical value. The use of proximate analysis as a method of designating and classifying coals is a typical example, and I am glad that the Institute of Fuel and the Institution of Heating and Ventilating Engineers have called a meeting to discuss the value of the proximate analysis, and the extent to which it can be expected to give reliable information about the performance of a coal. The present time is very appropriate for the discussion of this particular question, since many consumers, owing to the exigencies of the war, are obliged to use coals of which they have little or no previous experience.

By means of the proximate analysis, coal is divided into four constituents: "moisture," "volatile matter," "fixed carbon," and "ash." All of these are conventional quantities—that is to say, they do not represent separate chemical constituents of the coal, nor has their determination an absolute significance. The moisture determination and the ash content both present special difficulties. In the case of moisture, perhaps the most serious source of uncertainty is that of the preparation of the sample. The moisture content, according to our British view, is that contained in an air-dried sample. In this we differ from the Americans, who prefer, for reasons connected with the peculiarities of certain of their seams, to determine the moisture as mined. In Germany, also, the "as-mine moisture" is considered important. Our method of starting with an air-dried sample makes it necessary to prepare the sample under standardised conditions, and this is a precaution which, unfortunately, is very often neglected. The humidity of the atmosphere in air-drying may have quite an important effect on the apparent value of the free moisture.

Ash, as determined in the proximate analysis, is not a measure either of the mineral matter present in the coal or of the probable residue when the coal is burned. The determination of ash involves heating the sample to a temperature of about 800 deg. C. This means that, apart from burning off carbonaceous matter, the mineral constituents themselves are changed by the decomposition of carbonates, the loss of water of hydration of silicates and sulphates, the oxidation of iron pyrites, and various other minor effects. In extreme cases, these various changes may mean that the ash content as determined by proximate analysis differs considerably from the amount of mineral matter present in the coal. On the other hand, combustion on a grate is itself a different process from the ash determination, involving often far higher temperatures, and once again there may be a considerable difference owing to the more extensive decomposition and volatilisation which occurs in the fuel bed. Far more serious, however, than the question of quantity of ash is the difference in behaviour between the ash in a small sample and that in a bed of fuel. The fusion characteristics of coal ash, ground to a fine powder, may be completely and strikingly different from those observed in a furnace.

We must now consider the "volatile matter" and the "fixed carbon." This division represents an attempt to divide the coal substance into two constituents the behaviour of which is radically different when coal is carbonised or burned. It has been known for at least 150 years that different coals, when heated in the absence of air to a red heat, lose by thermal decomposition gases and carbonaceous vapours varying from 3 or 4 per cent. up to 40 or 50 per cent. of their weight. As this thermal decomposition is a most important property of the coal substance, it is very natural that it should have been taken as a basis for describing and classifying coals. The fixed carbon is determined by difference, so that we are concerned only with one measurement—namely, that of the "volatile matter," and the question we have to discuss can be stated: How far is the volatile content a reliable guide to coal behaviour?

This can be divided into a number of specific questions each of which must be answered before we can form a reliable opinion: (1) with what accuracy can volatile matter be determined?; (2) how far are published analyses reliable?; (3) to what extent do the properties of coal which determine its behaviour correlate with the volatile content?; (4) how far is any such correlation upset by factors which the proximate analysis fails to disclose?

The determination of volatile matter involves, in the first place, accurate sampling; secondly, accurate determination of moisture; and thirdly, suitable precautions in the actual estimation of volatiles. There are many pitfalls in each of these stages, and accurate results can only be expected if the procedure laid down in British Standard Specifications is followed with care, and the work is done by or under the supervision of experienced analysts. I think it is no secret that the members of the various committees which prepared the specifications were themselves astonished at the wide variations which were found when competent and experienced analysts made proximate analyses on the same coals by what they thought were identical methods. The analysis of low volatile fuels, such as anthracite and coke, presents difficulties so great as to require a special technique. An analyst trained to make reliable determinations of volatile matter in bituminous coal may produce very inaccurate results if given a sample of coke or anthracite.

Fig. 1.

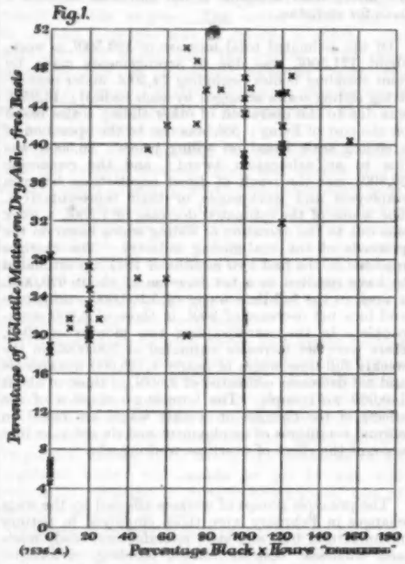
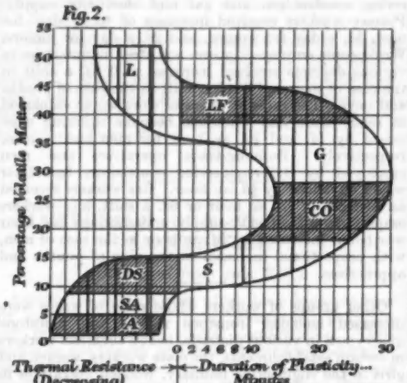

Percentage of Volatile Matter on Dry Ash-free Basis
0 20 40 60 80 100 120 140 160 180
Percentage Black x Hours "Immersion"
(1536.A)

Fig. 2.



The band in Fig. 2, above, is divided into eight classes of coal, as follows:—

A	Anthracite	CO	Coking Coals
SA	Semi-anthracite	G	Gas Coals
DS	Dry Steam Coals	LF	Long Flame Coals
S	Steam Coals	L	Lignites

It will be clear that proximate analyses which have not been made in accordance with a recognised standard procedure must be regarded as suspect. This applies especially to all results more than ten years old, even if they emanate from laboratories with the highest reputation. The volatile matter reported for many commercial grades of coal must be considered unreliable for several reasons, *e.g.*, (*a*) because the analyses are old and therefore the methods of test are suspect; (*b*) because a different part of the seam is now being worked from that at which the original samples were taken and the composition may have altered; or (*c*) the analysts were not fully trained in the latest standard methods. For these reasons, any analysis which has not been made recently in a laboratory known to have analysts trained in the use of the latest specifications must be regarded as liable to errors up to 2 to 4 per cent. in the volatile matter, and in some bad cases the error may be even greater. This uncertainty throws the gravest doubt upon any attempted prediction of the behaviour of coal where it is affected by properties which are very sensitive to the volatile content.

These extreme uncertainties apply only to analyses of unknown date and origin. When the determination of volatile matter is made by skilled analysts in accordance with standard procedure, a much higher degree of accuracy is possible. Recently, the Fuel Research Organisation published the results of an elaborate cross-checking of analytical methods carried out by its constituent laboratories. The accuracy obtainable as regards the proximate analysis is summarised in Table I, herewith. In giving these figures, Dr. Sinnatt added: "It should be borne in mind, however, that these figures are based on results obtained with one particular coal, and may need modification for coals differing appreciably therefrom in composition."

Table I.—*Range of Results and Differences in Proximate Analysis of Check Sample of Coal.*

Determination.	Average Result.	Reported Results. Minimum.	Reported Results. Maximum.	Extreme Difference between Laboratories.	Maximum Permissible Difference between Duplicates Odds, 10 to 1.
Moisture	0·58	0·5	0·74	0·24	0·16
Volatile matter	24·15	23·12	25·2	2·08	0·26
Ash	5·44	5·28	5·58	0·30	0·12
Fixed carbon	69·83	68·7	70·69	1·99	0·31

Quite apart from sampling and analytical errors, much confusion results from the different methods of stating the volatile content. It may be expressed in several ways, *e.g.*, (*a*) on the coal as received—that is, including ash and moisture; (*b*) on the dry basis; (*c*) on the dry ash-free basis; or (*d*) on the dry, mineral-matter free basis. Only the last of these gives the volatile matter as a property of the coal substance. There are various well known methods of allowing for the changes in mineral matter which can give rise to errors in estimating the amount of pure coal substance present in a given sample. The best known method is that proposed by Parr, and it involves the following corrections: Mineral matter = $1{\cdot}08 \times \text{ash} + 0{\cdot}55 \times$ combustible sulphur. This is based on the assumption that the loss of water of hydration amounts to 8 per cent., and that the combustible sulphur is all in the form of iron pyrites and is oxidised to ferric oxide.

A more accurate formula has been proposed by King, Maries and Crossley, as follows:—Mineral matter = $1{\cdot}09\,A + 0{\cdot}5\,S_{pyr} + 0{\cdot}8\,CO_2 - 1{\cdot}1\,SO_{3\,ash} + SO_{3\,coal} + 0{\cdot}5\,Cl$; where, as percentages of air-dried coal, A = determined ash; S_{pyr} = pyritic sulphur; $SO_{3\,coal}$ = original sulphate (SO_3); $SO_{3\,ash}$ = sulphate $(SO)_3$ in ash; and Cl = total chlorine.

To state the volatile content on the mineral-matter free basis, it is necessary to make a more elaborate examination of the coal than the simple proximate analysis, and therefore Dr. C. A. Seyler has proposed methods of approximating to Parr's basis which are adequate for any but exceptional coals. In what follows it will be assumed throughout, unless specifically stated to the contrary, that volatile matter has been reduced to Parr's basis.

I may have given the impression that the determination of volatile content is so difficult and unreliable that it is of little value in predicting the behaviour of coal. That was not my intention. In a very broad way, the volatile content provides an excellent classification. Low-volatile coals are free from smoke and give a very hot fire, but they are difficult to ignite and require a strong draught. High-volatile coals are smoky, but easy to burn. Coals with medium volatiles are strongly agglutinating and are the most suitable for making gas and coke. It is when we want to go beyond these broad generalisations and define any of these properties more accurately that the inadequacy of the volatile content becomes apparent.

Let us start with the most obvious effect—namely, the production of smoke. Fifteen years ago, the U.S. Bureau of Mines investigated the performance of various coals in 500 tests on central-heating boilers. These tests included a visual examination of the smoke by Ringlemann's method and measurement of soot deposits on the boilers. Fig. 1, herewith, shows how the smoke was related to the volatile matter. It will be seen that smokiness sets in at about 19 per cent. volatiles, and above this figure big variations occur. It would, for example, be unsafe to predict of a coal with 20 per cent. volatile matter that it either would or would not burn smokelessly on a domestic boiler.

* Paper entitled "How Far is the Proximate Analysis a Reliable Guide to Coal Behaviour?" read before the Institute of Fuel, in London, on April 3, 1941. Abridged.

With 38 per cent. volatile matter, the smoke produced varied from slight to the maximum which could be measured on the Ringlemann chart.

An interesting illustration of the unreliability of volatile content alone as a means of predicting smokiness is given in a report on open coal fires made by the Fuel Research Station. Discussing the factors which influence smoke, Blackie said:—"Although, under fixed conditions of grate design and flue length, a large number of other variables control the amount of smoke produced, the two most important appear to be the volatile matter content and the caking index. Up to a certain percentage there was a general tendency for the smoke to increase with volatile matter, but it was found that for coals of roughly the same volatile matter the smoke increased with the caking index. Thus, six of the coals, in which the volatile matter, less moisture, as charged, varied from 33·1 per cent. to 36·1 per cent., had caking indices (Gray-Campredon) of <5, <5, <5, 8, 17, 17, respectively, while the corresponding smoke emissions were 0·99, 0·81, 0·95, 1·37, 1·47 and 1·73 per cent. for wood and paper ignition, and 0·08, 0·43, 0·08, 1·27, 2·34 and 2·53 per cent. for the refuelling periods."

The next property to be considered is ease of ignition. Generally speaking, with coals over 20 per cent. volatile matter, differences in the ease of ignition have little practical importance. In the low volatile range, the ease of ignition turns out to be a composite property dependent upon at least four factors:—(*a*) The decomposition temperature, *i.e.*, the temperature at which the fuel begins to disengage combustible gases; (*b*) the rate at which combustible gases are evolved; (*c*) the total amount of combustible gases evolved; and (*d*) the ease with which the residual carbonised substance reacts with oxygen. Of these, only the third is directly dependent upon the volatile content.

A few years ago, in an investigation into the use of low-volatile coals in open fires, it was found that ease of ignition did not by any means correspond with volatile content. It has been found more ecently that the ease with which anthracite can be started up in portable gas producers could not be predicted from the proximate analysis. An investigation in progress into fuel reactivity shows that this is essentially a property of the carbon structure and not of the amount of volatiles released on decomposition. Although in low-rank coals the two properties run parallel to a great extent, this is by no means the case with high-rank Welsh coals. Table II, on this page, shows how the reactivity of six different anthracites, as determined by their heat of wetting with methyl alcohol, failed to agree with their volatile content.

We must now pass to properties of coal which have such different importance for hand firing and mechanical stoking—namely, the swelling and caking characteristics which make their appearance at about 40 per cent. volatiles and continue down to 12 per cent. or thereabouts. Scotch marine boilers are regularly fired with coals having every conceivable degree of caking and swelling characteristics. Non-coking Welsh coals and highly coking Durham coals are both excellent bunker fuels, and so are Scottish and Northumberland coals, which lie between the two. It is with the transition from hand-firing to mechanical stoking that swelling and caking characteristics assume importance. With some mechanical stokers, relatively small differences in these properties can make the whole difference between success and failure. Some carbonaceous materials, when heated, first melt and then decompose, while others decompose before melting. Some coals belong to the first class, others to the second. The melting temperature and the decomposition temperature are so close to one another in bituminous coals (see Fig. 5, on this page) that true melting is never observed, and it is better to speak of softening or a plastic stage. Decomposition takes place over a wide range of temperatures starting with the evolution of water vapour, carbon dioxide and monoxide, followed by paraffins and other hydrocarbons mixed with phenols and bases and ending at very high temperatures with hydrogen. Many organic substances when heated show a similar complex behaviour, but in none has this behaviour the same practical importance as it has with coal. The formation of a coke as opposed to a "char," lacking the characteristic cellular structure, depends upon a certain sequence of softening, decomposition and solidification. According to this sequence and the speed and intensity of its various stages, different coals swell without softening, soften without swelling, form hard cokes, weak cokes, swollen cokes, contracted cokes, and exhibit a whole variety of intermediate features, every one of which may have the utmost importance if the control of combustion depends upon a mechanical device and not upon the intelligent observation of a trained fireman.

Fig. 3.

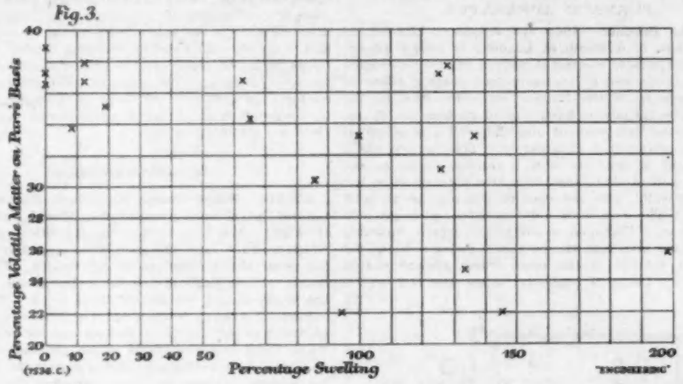


Fig. 5.

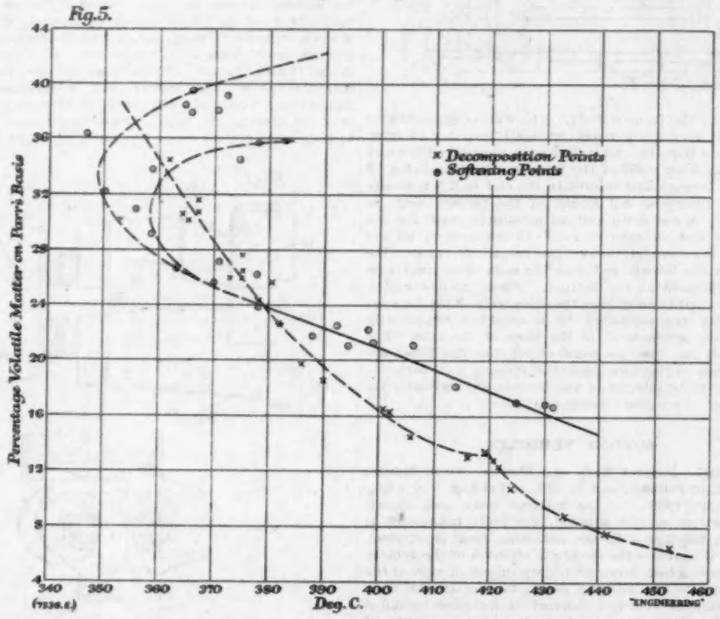
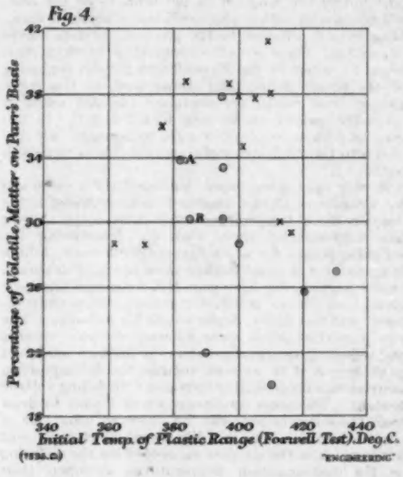


Fig. 4.



All these are differential effects—that is to say, they do not depend upon one basic property of the coal, but on differences between two basic properties; more precisely, the difference between the tendency to decompose on heating and the tendency to soften. With change in rank, which can be roughly measured by change in volatile content, the two basic properties will change progressively by stages which will not necessarily coincide. From this, it follows that there are likely to be regions where very small changes in the basic properties (which may be related to the volatile content) will cause profound changes in the secondary properties, which depend upon differences only. Over certain ranges, the swelling and caking characteristics of coal can be predicted with reasonable accuracy from the volatile content. In other ranges, no such prediction is possible.

Many attempts have been made in recent years to determine separately the tendency of coal to soften and to decompose. We may take as typical a recent Russian publication which attempted to show on a single chart the way different coals behave on heating. This graph, which is due to Matyushenko, is reproduced in Fig. 2, on the opposite page.

In this diagram the behaviour of coal on heating is shown in relation to the volatile content. Coals to the right of the zero point go through a plastic stage, which, in the particular apparatus used, lasts for a certain time under the given conditions of heating. The duration of plasticity is a measure of the relation between fluidity and decomposition. To the left of the zero point, coals do not become plastic but exhibit one or another form of thermal deformation, swelling, cohesion due to softening at the surface, decrepitation, and loss of mechanical strength.

I have tried to fit British coals into Matyushenko's diagram without much success, and I have only reproduced it in order to draw conclusions nearly opposite to those reached by the author. He suggests that his diagram enables the industrial behaviour of coals to be predicted from their proximate analysis, whereas

TABLE II.—*Reactivities and Volatile Contents of Anthracite Duffs.*

Anthracite Sample No.	Volatile Matter Per cent. (Dry Basis).	Reactivity by Heat of Wetting in Methyl Alcohol. (Cal./g.)
1	6·7	7·2
2	7·0	7·5
3	7·5	5·4
4	8·4	6·8
5	8·7	3·4
6	9·1	5·6

it is quite obvious that, if his diagram is correct, two coals with the same volatile content may behave quite differently. Thus, the horizontal line at 13 per cent. volatile includes non-softening coals, coals which swell without becoming plastic, and coals which become plastic to a marked degree. On the other hand, a degree of plasticity of 16 minutes duration is exhibited by coals from 13 per cent. to 43 per cent. volatiles.

It is obvious from these examples that, however interesting diagrams of this sort may be in showing the general changes which coals undergo as they increase in rank, they have little or no value at all in helping to predict the behaviour of coals from their proximate analyses. This absence of correlation between volatile content and thermal decomposition and the swelling and caking properties of coal is further shown in the diagrams, Figs. 3 and 4, on page 319, prepared by my assistant, Mr. Hawkaley. Fig. 3 shows the relation between volatile content and the swelling of coal by the Sheffield swelling test. Note particularly the range of 34 per cent. to 38 per cent. volatile matter within which different coals show variations from 0 per cent. to 120 per cent. in their degree of swelling. Fig. 4 gives the temperature at which coals begin to soften by the Foxwell test for the beginning of the plastic range, and shows how, in the range 28 per cent. to 30 per cent. volatile, the onset of plasticity varies from 360 deg. to 415 deg. C. In this diagram, references A and B refer to German coals, the circles to United States coals, and the crosses to British coals.

A very interesting paper, published three years ago by Evans and Phelps, reported measurements of the decomposition temperatures of various coals. Seyler has supplemented their work by determining the softening-points for a similar range of coals, taking temperatures of equal fluidity as an index of softening. In the diagram, Fig. 5, on page 319, the crosses represent Evans and Phelps' results for decomposition temperatures, and the circles, Seyler's data for softening. The two properties follow quite different curves; whereas the softening temperature shows a distinct minimum in the region of 32 per cent. volatile, the decomposition temperature progressively increases with falling volatile content. The main conclusion which I wish to draw from these curves concerns the observed behaviour of coal on heating. This is a differential effect dependent not so much on the absolute value of either the softening or the decomposition temperatures, as upon their difference.

(To be continued.)

CATALOGUES.

Fans.—From Messrs. Wagner Electric Corporation, 6,400, Plymouth-avenue, St. Louis, Missouri, U.S.A., we have received a catalogue giving particulars of their small fixed and portable electric fans for cooling and ventilating.

Rectifiers.—Messrs. Westinghouse Brake and Signal Company, Limited, Pew Hill House, Chippenham, Wiltshire, have sent us a pamphlet describing "Westalite" rectifiers, the chief feature of which is their small size and weight. The type described is an improvement on an earlier design and is suitable for larger power applications.

Magnetic Moulding Machines.—We have received from Messrs. British Insulated Cables, Limited, Prescot, Lancashire, a folder illustrating an addition to their range of electrically-operated moulding machines. In this roll-over type, squeezing, vibrating and heating are carried out electrically and the finished mould is automatically stripped on to the conveyor.

Self-Priming Pumps.—Messrs. Rhodes, Brydon and Youatt, Limited, Waterloo Engineering Works, Gorsey Mount-street, Stockport, have sent us a folder describing their self-priming pumps, suitable for direct-coupling or for belt drive. In these pumps, rotation of the impeller causes a portion of the pumped liquid to act as a fluid piston, gradually expelling the air until the suction main is positively exhausted, when the pump functions as an ordinary centrifugal pump.

The Engineering Outlook, IV: Addendum.—In our review, on page 184, *ante*, of some of the principal orders for heavy electrical plant, received or in hand during the past year, we omitted to mention the activities of Messrs. The Brush Electrical Engineering Company, Limited, Loughborough. This Company has informed us that, following the successful operation of the Brush-Ljungstrom sets installed at Brighton, they have received numerous orders for large sets from 20,000 kW upwards, and that the total capacity of turbo-alternators constructed by them during the year under review was 145,500 kW.

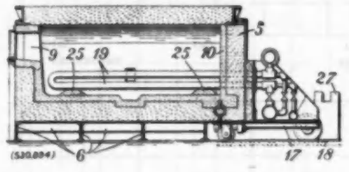
"ENGINEERING" ILLUSTRATED PATENT RECORD.

ABSTRACTS OF SPECIFICATIONS RECENTLY PUBLISHED UNDER THE ACTS OF 1907 TO 1939.

The number of views given in the Specification Drawings is stated in each case; where none is mentioned, the Specification is not illustrated.
Where inventions are communicated from abroad, the Names, etc., of the Communicators are given in italics.
Copies of Specifications may be obtained at the Patent Office Sales Branch, 25, Southampton Buildings, Chancery-lane, London, W.C.2, price 1s. each.
The date of the advertisement of the acceptance of a Complete Specification is, in each case, given after the abstract, unless the Patent has been sealed, when the word "Sealed" is appended.
Any person may, at any time within two months from the date of the advertisement of the acceptance of a Complete Specification, give notice at the Patent Office of opposition to the grant of a Patent on any of the grounds mentioned in the Acts.

FURNACE APPARATUS.

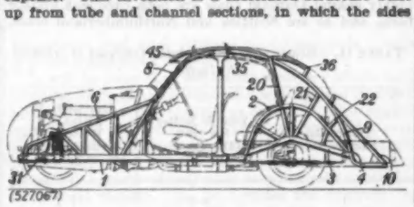
530,894. Furnaces. Stein and Atkinson, Limited, of London, and T. A. Booth, of London. (5 *Figs.*) July 5, 1939.—The furnace is a metal melting or heating furnace of the type in which internally-fired heating tubes in the lower part of the furnace are submerged in the metal. The furnace is fixed and of rectangular shape, and with the exception of one end wall 5 is mounted on a supporting grid of girders 6. The furnace has a filling spout in one side wall, a tapping spout in the opposite wall, and a large skimming opening 9 in the other end wall. This last opening can also be used for charging. The end wall 5 is mounted with its own lining 10 in a U-shaped metal frame, which embraces it along two sides and the bottom. Swing-bolts at the sides and bottom of the main frame engage slotted brackets on the wall frame to secure the end wall 5



tightly to the furnace body. The wall is supported in its frame upon a four-wheel carriage 17 running on guide rails 18 so that this end wall may be moved bodily away from the other walls of the furnace. Heating tubes 19 passing through and secured in the end wall 5 normally extend along the full length of the furnace near its bottom. A gas main and an air-supply main for the burners, and an exhaust hood, all common to all the tubes, are mounted above the front. Normally, the tubes in the furnace rest near the ends upon transverse ribs 25 formed on the bottom. When the end wall 5 is moved bodily away from the other walls of the furnace, the tubes are supported on a cross-bar temporarily placed on pedestals 27 at the sides of the rails. The end wall can then be removed so that the tubes are completely withdrawn from the furnace and both the tubes and the interior of the furnace are accessible for cleaning. (*Accepted December* 24, 1940.)

MOTOR VEHICLES.

527,067. Integral Body and Chassis. Aston Martin, Limited, of Feltham, and C. Hill, of Feltham. (4 *Figs.*) March 30, 1939.—In the integral body and chassis construction usually adopted, the body framework is pressed, together with the panelling, from sheet steel, so that it provides the structural strength of the vehicle. This construction, however, is only suited, in view of the high cost of the pressing plant, for use in the mass production of vehicles, although it increases torsional strength and results in considerable saving in weight and expense. This invention is a fabricated structure built up from tube and channel sections, in which the sides



of the body are constituted by girders the upper and lower chords of which are strongly cross-braced. The lower chord 1 of each of the two girders runs horizontally from the front of the body to just in front of the rear wheel, where it divides, and one portion 2 is carried in a curve over the top of the wheel and the other 3 is carried behind the wheel and re-unites at 4 with the first portion, the chord then continuing still farther rearwards to support the tail of the car. The upper chord 6 of each girder springs from the front end of the lower chord and rises to the bottom corner of the windscreen frame. The chord is then carried upwards through the pillar 8 and then passes in a smooth curve over the top of the two doors. Finally, the upper chord branches into two parts, of which one, 9, curves downwards to meet the lower chord at the point 4 and the other, 10, slopes downwards to meet the end of the lower chord. The upper and lower chords are connected in front of the windscreen by three vertical bracing posts and two diagonals. The windscreen pillar 8 is also continued down to the lower chord and braced. Midway along the side of the body a vertical pillar connects the upper and lower chords, and to it the two doors are hinged. At the rear, three braces 20, 21 and 22, connect the chords. The two side girders are connected by 15 main cross-braces. The cross-brace 31 forms the front axle from which the front wheels are independently sprung. The cross-braces 35 and 36 are connected, respectively, by diagonal stays to the upper chords of the two side girders, and a member 45 extends forwards to the windscreen frame from the centre of the cross-piece 35 to support the roof panelling. The tubes of the framework do not conform accurately to the shape of the panelling, which is supported from them by adaptor pieces. (*Accepted October* 1, 1940.)

MISCELLANEOUS.

529,416. Range-Finding Binoculars. Barr and Stroud, Limited, of Glasgow, and J. W. French, of Glasgow. (4 *Figs.*) May 31, 1939.—The invention is a device which is built into one limb of a binocular to enable the range of the object to be determined. The tubular casing of one limb of the binocular is cut short and the range-finding device is fitted to it. The device consists of a casing containing an objective similar to the objective of the other limb and an annular prism, having plane front and rear faces which are inclined to one another. A bracket on the casing carries the mechanism for moving the annular prism, which is mounted in a holder that can be rotated about the optical axis. The prism is rotated by a worm engaging the holder and driven through bevel gears by a milled head 10. Two scale drums 11 and 12 rotate with the head and are graduated in range values. They register with a stationary scale bar having two sets of scale markings 13 and 14. The observer sees in the field of view two images of the target, one a normal image formed by the light passing

Fig. 1.

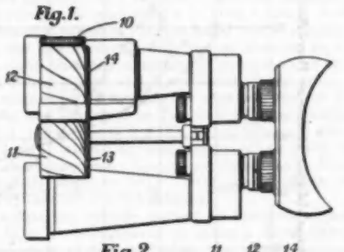
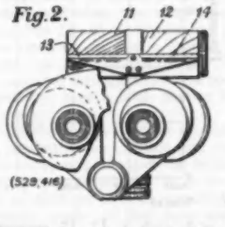


Fig. 2.



through the opening in the annular prism and a secondary image formed by the light which passes through the prism. Rotation of the prism displaces the secondary image in the field of view so that, for example, where the range of a ship is required and the height between the water line and the funnel top is known, the observer brings the water line of the secondary image on to the funnel top of the normal image, and then reads off on the range scale 11, the range appearing against the known target height on the scale 13. If, however, the target height is not known, the range can be estimated by referring to the horizon, in which case it is assumed that the observer's height, say, above water level, is known. In this case the observer turns the annular prism to bring the horizon of the secondary image into coincidence with the water line of the normal image. He then reads off the range value on the scale 12 against his known height on the scale 14. The prism and its holder are carried by a support so that the prism can be swung through a right angle out of the line of sight. (*Accepted November* 20, 1940.)